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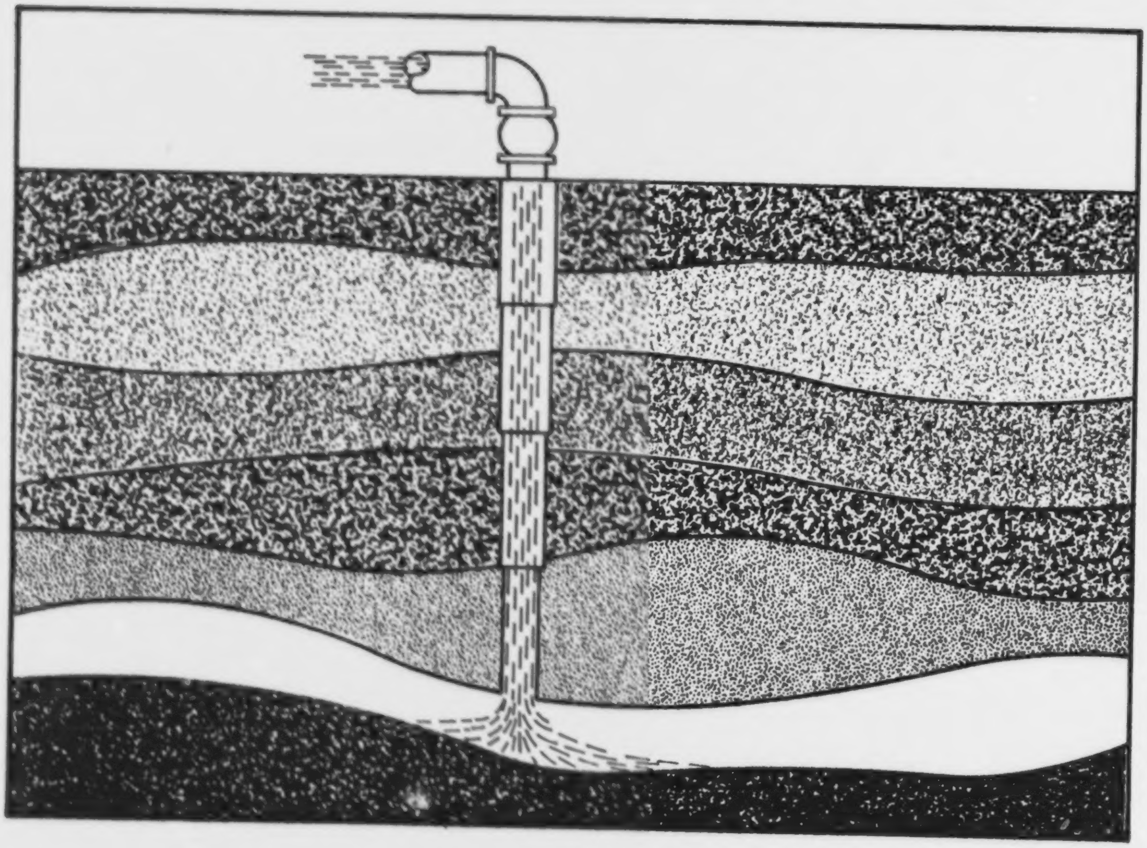

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PUBLIC POLICY ON
GROUND WATER QUALITY PROTECTION

Proceedings of a National Conference

April 13-16, 1977

at

Virginia Polytechnic Institute and State University

Sponsored by
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Edited by
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Introduction & Overview

The nation's ground-water resources are being degraded by a wide spectrum of sources and causes. Some are natural sources and causes, but many are due to man's activities. Although ground-water pollution has not received as much attention as surface-water pollution, problems associated with it may be much more significant. For instance, surface-water pollution often may be easily corrected at the source of pollution or by treatment, whereas ground water may remain polluted for decades or even centuries after a source of pollution is removed. Restoration of ground-water quality is difficult and very expensive. Therefore, scientific and economic goals should be based on protection rather than restoration of ground water. Protection of ground water is, then, in everyone's best interest.

While the nation has made significant strides in controlling some aspects of ground-water pollution, there are a number of pollution sources and other problems which cannot yet be fully evaluated in terms of their pollution potential because of the lack of detailed information and the inability to make the necessary evaluations. While federal and state regulations provide for some quality control, there is no overall comprehensive management of ground-water resources. It must be recognized that protection of ground-water quality cannot be fully achieved solely by regulation and control of disposal wastes. Likewise, we can no longer simply shift around temporary problem solutions; rather, we need permanent solutions to waste-disposal problems. The full benefit of these resources with adequate protection of quality can be achieved only with comprehensive, conjunctive management of both surface and ground waters.

This conference brought together, by invitation, a group of persons having recognized expertise in ground-water quality and a concern for related public policy issues. Through presentations and discussions, they considered such issues as: (a) the extent of degradation allowable, and ramifications associated with specific policies; (b) policies regarding various sources of contamination and their impact on ground-water quality; (c) the potential effectiveness and long-range implications of specific federal and state programs concerning ground-water quality protection, and (d) weaknesses in existing laws and administrative arrangements.

Several speakers, including keynote speaker Jack Keeley, emphasized that restoration of ground-water quality is difficult and expensive. Thus, our policy should be based on the protection of quality rather than on restoration. To do that, sources of contamination must be identified and their impact evaluated so that protection is made possible through controlling the amount of water withdrawn and the quantity and quality of waste returned. Means must be developed whereby the intrinsic value of ground water can be determined and then the goal of protection and possibly restoration can be put in proper perspective.

A major issue in ground-water quality protection continues to be the extent of degradation allowable and ramifications associated with specific degradation policies. Acceptance of any public policy on ground-water protection wherever it is on the spectrum between non-degradation and laissez-faire rests on a foundation of understanding. Contrary to some professional opinion, Richard Rhindress believes we are at a state-of-the-art where we can, and must, immediately assault the challenge of education to bring about public understanding to support ground-water policy. He believes, also, that we need a non-degradation policy because ground water is an essential natural resource--a resource that has been vital to the establishment of much of America. The mobility of our society, the dispersal of our industry, and much of our agriculture depend upon a readily available supply of clean ground water. In addition, and from a social standpoint, a strict policy of non-degradation for ground water speaks directly to a right all should have--the right to live in a clean environment, hospitable to human life. A strong non-degradation policy, he says, is an essential tool in bringing us toward a real and permanent solution.

Can we accept the non-degradation approach when apparently there will always be a need for well designed and operated land disposal areas to handle that portion of wastes not processible by resource recovery systems, to handle the residue generated by the system, and for use when the system has a breakdown? Thus, how do we effectively establish a policy that deals with placing residuals on land? Joseph Boren says the only approach is a limited degradation policy. In determining the location of a disposal area on a case-by-case basis, the decision might be made to write off a portion of ground water or an aquifer as a sink for disposal. This is a possibility that one must contemplate especially when considering a policy of limited degradation.

A limited degradation policy means there will be risks and they must be taken. Boren believes the risks involved with a limited degradation policy can be identified and minimized. Even though economic and social costs are not fully determined, they should be negligible if adequate consideration of political and social ramifications have been factored into disposal decision.

While a full laissez-faire approach may not be environmentally feasible, the limited degradation approach should receive serious consideration. Boren sums up the limited degradation approach by stating that the problem of limited degradation is to establish with reasonable certainty that no water which is contacted by pollutants will be significantly altered to preclude existing or reasonable anticipated use by persons or to interfere with the physical, chemical, or biological integrity of waters in direct contact with living organisms.

Policy Regarding Sources of Contamination

Several sources of ground-water contamination can be readily identified. Known control technology to prevent much of this contamination is also available. However, knowledge of the extent of impact on ground-water quality of many of these contaminants is unknown. Several speakers provide an assessment of the current state of policy with respect to the major identified sources.

Pennsylvania has passed several laws to prevent pollution of that state's waters which received acid mine drainages from underground and surface coal mines. The extent to which existing policy takes into consideration the impact on ground-water quality is difficult to answer because any type of mining can and does affect ground water. Pennsylvania is living with problems created 150 years ago and complicated by the complex, plumbing-like interconnections of surface and underground mining. The complex geology and ground-water conditions are not totally understood. It is also important to understand the difficulty of mining for any mineral without having some effect on water quality and water quantity.

The sources of pollution from mining will vary as widely as does the geology of this country. Geochemical studies, and information on barrier thickness and stability, multi-seam coal mining, synclinal basin dewatering, and new techniques of mining are needed to adequately evaluate the effect of mining on water quality. Only then can policy be evaluated and adequate policies developed to fully protect ground water.

Regulation of injection and abandoned wells is a major issue for some states. Texas is one of those states. Before a permit is issued by the Texas Railroad Commission for subsurface disposal injection wells, an evaluation by the Texas Water Quality Board staff is made to assess ground-water implications. The board believes that subsurface injection is a practical and feasible method of disposal of certain waste when the overall project is properly designed, constructed, operated, and monitored.

A key factor which must be considered in an injection well project is the safe abandonment of it, and its own effect upon improperly plugged and abandoned wells in the area of the disposal well. Underground injection of liquid waste is by no means an exact science, since no one is able to see below the surface. Tools and instruments are available, however, to allow for interpretation of the otherwise unknown. Jerry Mullican states that sufficient knowledge is available that, with proper safeguards, subsurface injection is an environmentally sound method of disposal of man-made waste because the waste can be isolated from man's water, air, and food.

Another potential pollutant source is residuals from oil well operation and maintenance. Primary water pollutants in oil well operation and maintenance are oil and salt water. Also, during the first two decades of this century, technology did not adequately protect freshwater reservoirs from saltwater intrusion resulting from oil operations. However, as the technology for performing pollution-control tasks advanced, state regulations became more and more stringent. In view of the present situation, Verlin Meier believes the development of a national policy for protection will court disaster if it is uniform, rigid, and inflexible. What is appropriate for one state could be inappropriate for another. Under any policy, state and federal regulations pertaining to ground-water protection from oil well operation and maintenance need to be coordinated.

In our past efforts to eliminate pollutants from air and streams, the tendency has been to move pollutants toward areas of least regulation such as ponds, pits, and lagoons. We can no longer simply shift around temporary problems but must find permanent solutions. Policy should allow these impoundments to operate for their intended purposes without damaging the environment.

The Safe Drinking Water Act and the Resource Conservation and Recovery Act address some of the issues of what substances go into impoundments and where the impoundment is located. Present policy toward control of ground-water pollution seems to focus on certain physical structures or mechanisms rather than on controlling pollutants, as in surface-water regulations. Yet, under any policy, the stringency of design requirements must continue to reflect the potential for contamination. Arnold Schiffman believes the national policy for waste impoundments should be that they work for intended purposes without adversely impacting ground water. Also, he continues, policy must establish priorities for protection by delineating those aquifers most susceptible to contamination by impoundments and the substances and circumstances most likely to cause serious damage.

As greater attention has been given to non-point sources of pollution, agriculture has come to be regarded as a primary pollution factor, especially with respect to the enrichment of water by nitrogen. Knowledge about the use of agricultural chemicals and their subsequent fate is incomplete. Thus, a considerable effort is now being made nationwide to determine the relative importance of agricultural and other non-point sources of contaminants. Keith Porter reports on results of one such study for the Nassau-Suffolk region of Long Island, particularly that part of the program which is attempting to assess the impact of agricultural chemicals on ground water.

Urban runoff from construction areas, impervious surfaces, and land fills has been identified as a major pollution potential in many areas. Therefore, people who are concerned with maintaining ground-water quality should directly enter and influence the land use planning game, including its political decisionmaking process, and push it farther along the track for such things as respect for and protection of aquifer recharge areas. Management of non-point sources, quite often matters of municipal and construction good housekeeping, would help to maintain the quality of water going back into the ground. Harold Wise contends that non-point source management as part of land use planning over the long run will prove to be the most critical part of the clean water program in this country. We are trying, he says, to position land use planning so that it commits resources in the real world and protects and enhances our environment at the same time.

Land dispposal of wastewater and sludge has become a popular topic for many communities, particularly small communities. While land application appears economically feasible for these communities, we must consider the ground-water pollution potential of such practices. During the 1950's and 1960's, the progressively stringent quality goals set by the state and federal governments for the discharge of wastewater into receiving streams made the alternative of land disposal particularly appealing to municipalities and industries. Regulatory agencies were ignoring land disposal practices. Policy was on a case-by-case basis, and uncontrolled land application of wastes caused significant ground-water problems in several instances. These problems are discussed by Grover Emrich in his text.

Requirements of Public Law 92-500, which require consideration of land application as an alternative and the potential economic advantages, also have stimulated interest in the use of land application systems. No distinct policy on ground-water quality protection from land application has been articulated. However, according to Emrich's comments, if the EPA policy that any land application or land utilization technique must comply with criteria designated to protect ground water, land disposal and ground-water quality must be considered together. A critical point is the decision as to where the ground-water system will be sampled for monitoring. Shall the ground-water quality standard be established immediately below point of land application, or shall a mixing zone be established similar to that of surface waters? Emrich contends that unless a mixing zone is allowed for ground-water discharges, many land treatment systems may be eliminated from practical consideration. Ground-water standards, he continues, are needed to ensure that sufficient treatment is provided and that the ground water is not drastically altered in quality.

Implementation of Controls

Several federal and state programs with an impact on ground-water quality protection have received considerable attention, particularly since 1973. Six speakers analyze the potential effectiveness and long-range implications of specific federal programs, state programs, the interstate commission approach, and a local approach to ground-water quality protection.

John Hernandez provides a concise explanation of the National Safe Drinking Water Act. Purpose of that legislation is to assure that water supply systems serving the public meet minimum standards for the protection of public health. While P.L. 92-500, the Federal Water Pollution Control Act Amendments, provides for ground-water quality monitoring programs and for EPA guidelines for disposal of pollutants in wells and subsurface excavations, the Safe Drinking Water Act requires designated states to adopt regulations to control underground injections. The intent was that the various states have enforcement responsibility for these aspects of ground-water protection. Hernandez provides also an interpretation of EPA's proposed Underground Injection Control (UIC) regulations, which are designed to implement the Safe Drinking Water Act.

Kent Ballentine provides a review of the purpose of federal statutes, other than Safe Drinking Water Act, which bear on ground-water quality protection. Contents of four sections of P.L. 92-500, the most inclusive act, impact on ground-water quality protection. Section 208, concerning areawide waste treatment management, requires plans that must include the processes to control ground-water quality. Section 303 requires a continuing planning process which includes requirements for the above 208 plans. Section 304 requires the issuance of guidelines on things such as disposal of pollutants in wells or in subsurface excavations. Section 402 provides permitting for certain disposal of pollutants into wells.

Other legislation includes the Toxic Substance Control Act; the Resource Conservation and Recovery Act; the Federal Insecticide, Fungicide, and Rodenticide Act; the Atomic Energy Act; the National Environmental Policy Act; and the Control of Ground-Water Quality Protection on Federal Lands and on Federal Facilities Act. Ballentine appropriately summarizes the review by stating that it would appear, for most situations in which federal action is involved, some consideration of ground-water quality is authorized. Whether or not that consideration is sufficient depends on one's perspective.

Most states provide for some degree of ground-water protection. Carlyle Westlund and John Moore provide a discussion of the contrasting approaches as applied in Pennsylvania and Illinois, respectively.

The state ground-water protection program began in 1963 as part of Pennsylvania's water pollution control program. Wastewater treatment project reviews include consideration of the ground-water element. Much of the responsibility has been placed on the applicant, who very often must hire professional expertise. Rules and regulations have been developed to control serious problems related to wastewater impoundments, sanitary landfills, petroleum storage, mining, and land disposal of wastewater. To accomplish the abatement portion of the program, their goal is to require the responsible party to make a concerted effort and to use all practical means to restore ground water to its unpolluted condition. By requiring the responsible party to develop the cleanup procedure, they expect to accomplish much more ground-water restoration than would be possible if the agency did the work.

The prevention part of the program involves: (1) the review and investigation of proposals for land disposal of solid and liquid waste and applications for mining and mine drainage permits, and (2) the development of guidelines, rules and regulations, and standards to prevent future ground-water pollution and maintain existing ground-water quality to the highest degree practicable. However, at present the agency does not have legal remedy for regulating ground-water use. Uses can have a deleterious effect on quality.

The Illinois Division of Land Pollution Control is responsible for the safe, economical, and environmental disposal of domestic wastes, liquid wastes, and hazardous wastes. The division has permitting authority in each of those areas as well as permitting authority for underground injection wells. The agency staff has the ability to plan, regulate, and enforce. They also possess the necessary research capability. Permits for land fills are examined in terms of traditional planning and zoning considerations, transportation and noise impact, and local property value, as well as thorough engineering and hydrogeologic evaluation. According to Moore, Illinois is trying to tie in existing programs with new initiatives and pragmatism to develop a program that allows for the disposal of great quantities of society's residues in concert with the development of a state ground-water policy.

Jerrald Hollowell and Joachim Tourbier discuss the interstate commission and the local approach to ground-water protection. Complexities of planning for water quality are multiplied when more than one state or political jurisdiction is involved. Unique institutional arrangements may aid the planning process. For example, existing requirements of each signatory party for the Susquehanna River Basin Commission appear adequate to protect ground-water aquifers from shallow wastewater disposal. Each member has the capability to effectively implement either existing or new regulations and programs aimed at improving the protection of ground water from shallow underground discharge of wastewater.

Although the Susquehanna Commission has the legislative authority to assume jurisdiction to protect and improve water quality, according to Hollowell, it has chosen to review and evaluate the signatory parties' regulatory programs governing underground waste discharges, rather than to assume a more active regulatory role.

Joachim Tourbier contends that land use decisions in the U.S. will continue to be made at the local level. Therefore, in order to implement ground-water resources protection measures, locally associated benefits need to be communicated to the public. The only way to bring about effective local control is not to separate water issues but to establish neighborhood care programs and ordinances that address themselves to interrelated problems posed by reduced infiltration and ground-water recharge, stormwater management, and the control of non-point sources of water pollution.

Tourbier provides a detailed example of the local approach for ground-water protection. That approach was the adoption of a surface and ground-water drainage code in the Christina Basin in New Castle County, Delaware.

Institutional Arrangements for Ground-Water Protection

The National Water Commission considered a wide variety of subjects relating to the water resources of the nation and water resource development and utilization. Considerable emphasis was given to management of ground-water resources and protection of ground-water quality. Harvey Banks discusses the findings and recommendations of the Commission. Excerpts from the Commission report indicate that in many states ground-water law is inadequate to allocate the resource among competing users and is unresponsive to the problem of excessive use. Although ground-water pollution has not received as much attention as surface-water pollution, the report observes, it may be more significant. Also, relatively little law has been developed for the regulation and management of interstate aquifers. Deficiencies exist in the amount of data and information about ground-water resources in general.

Specific recommendations for regulatory control of ground-water quality included the recommendation that policy should be based on the principles that (1) water is polluted when its quality has been altered by the activities of man to such a degree that reasonable present and prospective uses as designated by public authorities are impaired, and that (2) the objective of pollution control should be to protect designated uses. Receiving-water standards should be sufficiently high to protect all existing uses and all reasonably foreseeable future uses, but should also take into account the economic, social, and environmental costs of achieving them.

Banks provides a list of 20 recommendations for ground-water management but believes the NWC did not give adequate attention to non-point sources of pollution nor to the extensive institutional restructuring of government necessary to carry out the Commission's concept of comprehensive management. To his knowledge, no state has, since the 1973 report, enacted a body of law under which comprehensive, integrated management of surface and ground water, in both quantity and quality, could be achieved. Only through comprehensive, conjunctive management of surface and ground water can the full benefit of these resources, with adequate protection of quality, be achieved.

Jay Lehr provides a perspective regarding present institutional arrangements and additional institutional requirements now and in the future. In his opinion, there is less need today for federal regulation of the nation's water than any time in history. That is because today's environmentally conscious citizenry no longer needs the protection of "big brother" in Washington as in the past. States acting independently can do more themselves with only moral and financial support from the federal government. He contends that we may be approaching the point where the least rigid regulation is the best regulation because, as states become concerned about potential ground-water pollution problems, good things are happening without the further prod of federal legislation.

Whether or not present institutional arrangements and present consideration of ground-water quality by federal and state statutes and rules and regulations are sufficient depends on our perspective of the ground-water quality problem. Hopefully, the information in the full text of the conference paper will help decide the direction of future ground-water protection policy, whether it be federal action, state action, or local action.

The full text of the conference presentations and the ensuing discussions follow in these proceedings. The information will provide a foundation to support recommendations on future policy for ground-water quality protection.

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June 1977

Keynote Addresses

MAGNITUDE OF THE GROUND-WATER CONTAMINATION PROBLEM

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INTRODUCTION

We are aware of the protracted effect of contamination on ground water as compared to its surface counterpart, and that restoration of underground water quality is difficult at best and always expensive. Indeed, in almost all cases the cost of restoring the integrity of ground-water quality exceeds its intrinsic value. It follows that our scientific, legal, social, and economic goals must be based on the protection of ground-water quality rather than its restoration.

This concept necessarily requires that the possible sources of contamination be prioritized according to their severity and that scientific and legal means for control be made available. Finally, the use of a ground-water resource must be optimized, according to existing economic and social constraints, by controlling the amount of water withdrawn and the quantity and quality of waste returned.

SOURCES OF GROUND-WATER POLLUTION

The ground-water pollution problems to be outlined here were essentially gleaned from six reports on the subject. One is a Report to Congress provided in January, 1977. The remaining five reports discuss ground-water availability, use, and background quality for various geographical areas of the United States. The significant pollution problems for each are discussed and placed in priority. The five geographical areas studied are shown on Figure 1 and the prioritized pollution problems for each are presented in Table 1.

Three additional studies are planned which will cover the Midwestern States, the North Central States, and Hawaii and Alaska. The Southwestern report was completed in 1971, followed by the South Central in 1973. Reports covering the Northeastern and Northwestern States were completed in 1974 and that for the Southeast was completed this year.

Some problems indigenous to one area may not exist in others but several sources of ground-water contamination are dominant at a high or moderate

FIGURE 1

Locations of Completed Ground-Water Investigations
in the United States

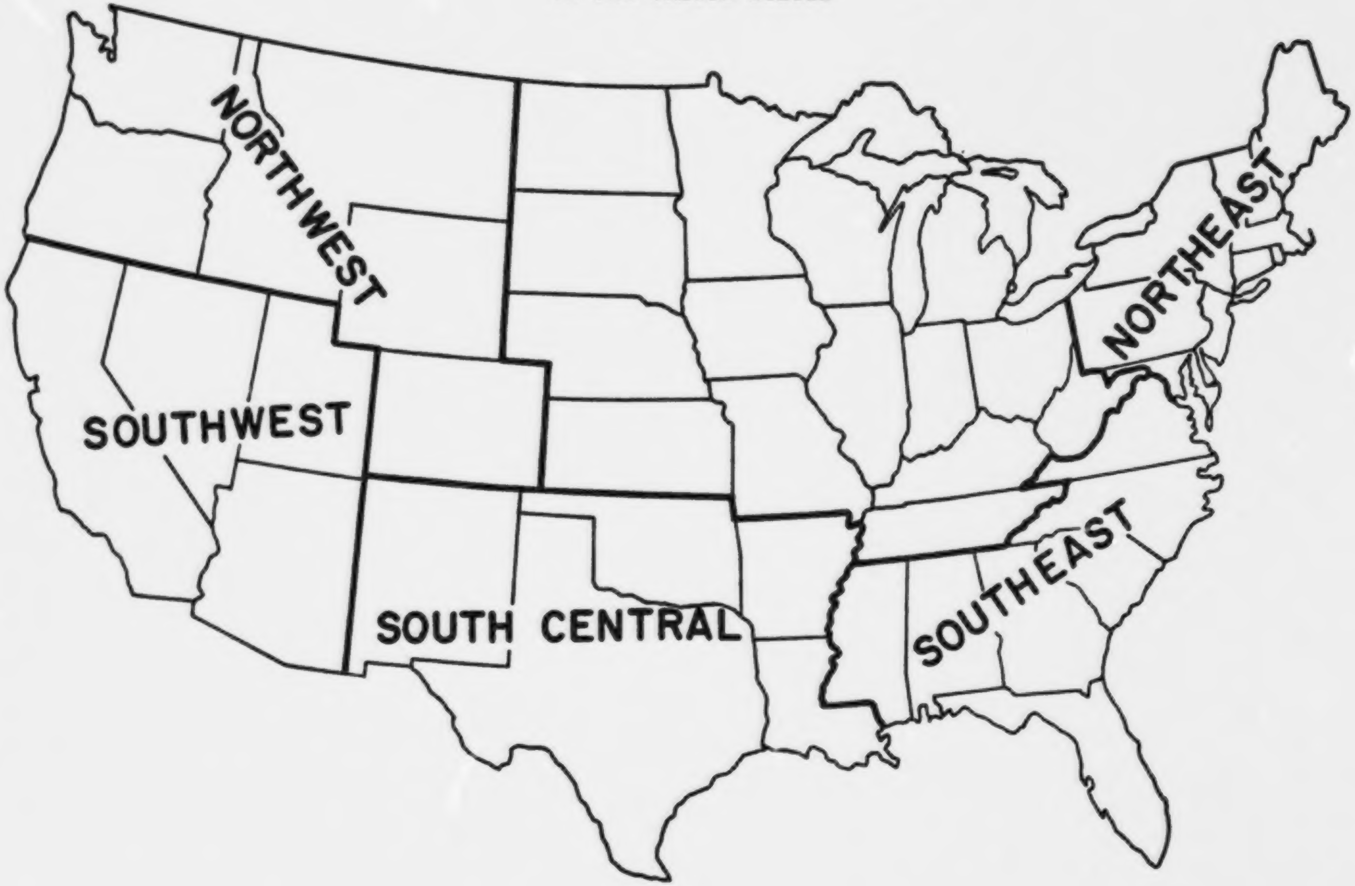
NORTHWEST
SOUTHWEST
SOUTH CENTRAL
NORTHEAST
SOUTHEAST

TABLE 1

Priority Sources of Ground-Water Pollution

Southwest	South Central	Northeast	Northwest	Southeast
1. Natural Leaching	Natural Pollution	Septic Tanks & Cesspools	Septic Systems	Septic Systems
2. Irrigation Return Flow	Oil Field Brines	Buried Pipelines & Storage Tanks	Sewage Treatment Plant Discharge	Urban & Industrial Landfills
3. Sea Water Encroachment	Well Construction	Highway Deicing Salts	Irrigation Return Flow	Surface Impoundments
4. Solid Wastes	Overpumping	Landfills	Dryland Farming	Drainage Wells & Abandoned Water Wells
5. Disposal of Oil Field Brines	Irrigation Return Flow	Surface Impoundments	Abandoned Oil Wells & Test Wells	Fertilizers & Pesticides
6. Animal Wastes	Land Application of Wastes	Spills & Surface Discharges	Brine Injection	Leaks & Spills
7. Accidental Spills--Hazardous Materials	Solid Wastes	Mining Activity	Disposal Wells	Brine Injection Wells
8. Water from Fault Zones & Volcanic Origin	Evapotranspiration from Native Vegetation	Petroleum Exploration & Development	Surface Impoundments	Feedlots
9. Evapotranspiration from Native Vegetation	Animal Wastes	Salt Water Intrusion	Mine Drainage & Mine Tailings	Irrigation Return Flow
10. Injection Wells for Waste Disposal	Waste Lagoons	River Infiltration	Urban & Industrial Landfills	Abandoned Oil & Gas Wells

degree of severity in each area investigated. Among these, septic tanks and cesspools, petroleum exploration and development, landfills, irrigation return flows, and surface waste impoundments appear to be the most troublesome problems.

The application of municipal and industrial sludges to the land has not been of major concern in the past but is expected to be so in the future due primarily to the federal legislation seeking to eliminate stream discharges by 1985. Similarly, coal mining activities are increasing in the United States, due to the energy shortage, and are expected to present greater ground-water pollution problems in the future.

The four pollutants most commonly reported in these five regional investigations are chlorides, nitrates, heavy metals, and hydrocarbons. This brings into focus our need to more actively include organic and biological parameters in future studies.

Individual Sewage Disposal Systems

Over 17 million families in the United States are served by septic tanks or other means of subsurface seepage. This accounts for something over 30 percent of the population.

Assuming that 50 gallons per capita are discharged to these systems daily, it can be estimated that nearly 3.5 billion gallons of waste are introduced directly into the subsurface environment each day. Even this does not account for other large contributions by commercial and industrial sources.

Traditionally, septic tank studies have been concerned primarily with chlorides, nitrates, and members of the coliform group as indicators of pollution. Considering the magnitude of this problem and the diversity of chemicals being introduced into the home each year, more sophisticated indicator parameters will have to be used in future studies.

Petroleum

The exploration and development of oil has played a long and important role in the United States. The industry has changed tremendously since its early days, when little attention was paid to the efficiency of recovery or to the consequences of environmental degradation.

The major water-pollution problem stems from brines recovered with crude oil at an average ratio of about 10 to 1, depending on the age of the well. In the early days, these brines were discharged to streams or pits or anywhere else and allowed to run where they might. Today most brines are reinjected for disposal or to repressure an oil horizon in secondary recovery projects.

The number of active and abandoned oil and gas wells, salt-water disposal wells, and holes drilled for exploration number in the hundreds of thousands. These holes can allow salt water and fresh water to interchange when the casing is missing or has corroded. Many of these old and often forgotten holes continuously discharge brines to the surface. Although the use of unlined brine disposal pits has essentially been stopped, they will continue to leach salts for many years to come.

We do not have adequate means, and in many instances knowledge, to locate and adequately plug the thousands of wells which were abandoned in the years before regulations came into being. The problem is so extensive and complex and our knowledge to cope with it is so meager that this will continue to be a major source of contamination.

Landfills and Surface Waste Impoundments

There are a number of other problems which cannot yet be fully evaluated in terms of their pollution potential due to a lack of detailed information and, indeed, the ability to make the evaluations necessary. Among these are included the disposal of municipal and industrial waste either in landfills or impoundments. There are current investigations, particularly concerned with industrial landfills, which are returning some rather disturbing facts.

The basic problem in dealing with these sources of contamination, and some of those already mentioned, is the technical inability to sample and analyze for parameters not ordinarily considered in ground-water investigations. There are thousands of organic chemicals associated with municipal and industrial wastes in both the liquid and solid states. Characterizing the total aerobic and anaerobic microbiological population is beyond the economic and manpower capabilities of most regulatory bodies. When we realize that the subsurface transport processes of these parameters and their degradation products must be understood before adequate waste management schemes can be undertaken, our problems are exponentially complicated.

Agricultural Sources

Ground-water contamination from agricultural sources is primarily concerned with salts, fertilizers, and pesticides from crops and manure sources in high-density animal feeding operations. Of course, pesticides and fertilizers result from management practices, while salts necessarily stem from the quality of available irrigation water.

Intensive animal feeding operations involve the production of large quantities of wastes. This is particularly true of cattle, swine, and chicken operations. In addition to the obvious contaminants in these wastes, they also may contain additives such as hormones and antibiotics.

Water Well Construction

A major problem found in almost all parts of the country is the integrity of water wells. Many were constructed without proper consideration of sanitary conditions, while others failed in this respect after many years of service.

Wells in which the casing has failed or was inadequate when constructed allow for the interchange of waters between fresh and salty aquifers or the contamination of ground water from surface sources. These problems have been noted particularly along the coasts, where salt-water intrusion has occurred, and in areas where salt water underlying fresh water was given an avenue for interchange.

There is an obvious need to develop technology to locate and plug those wells which were abandoned before records were kept. There is also a need to develop an economical way to restore the integrity of those wells still in service, particularly in situations where the owners cannot afford to construct a new facility.

Highway De-icing Salts

The use of salts to control highway ice is confined to the northern states and is apparently of more concern in the Northeast than the Northwest. As an example, Massachusetts used more than 20 tons per single-lane mile during a winter season, while the Northwestern states used a tenth of that amount.

Highway salts enter ground water either by infiltration of the salt-laden runoff or from precipitation on salt piles at central storage areas. Equipment modification and driver education have been successful in reducing the amount of salt distributed during a single winter storm, and efforts are being made to cover or otherwise improve salt storage facilities.

General

It is important to note that the problems, as prioritized in the five areal reports, have not been selected on the basis of hard statistical information. Such information simply does not exist. Problems associated with the exploration and development of oil and gas have been well documented primarily because of their existence over long periods of time and the relative ease of making chloride determinations. Industrial lagoons and landfills, on the other hand, have enjoyed relative anonymity due to their inaccessibility and the complexity of the waste involved. Many other potential sources of groundwater contamination were found to be sparsely covered in the literature or the files of regulatory agencies. For these reasons, priorities were established mainly on the basis of the experience of those authorities who have worked in the areas studied.

ECONOMICS

Establishing the economic consequences of ground-water pollution proves to be one of the most perplexing problems with which we are forced to deal.

The benefit of restoring polluted surface waters can be roughly established by equating it to the cost of treating the source of pollution or obtaining an alternate source of water, giving due credit to aesthetics and recreation. The decision to restore surface water is always made with the realization that the quality will be restored soon after the sources of pollution are removed.

Obviously the benefit exceeds the cost, because polluted streams have been restored all over the world.

This philosophy does not hold with ground water, which may remain polluted for decades or even centuries after the source of pollution is removed. There are no benefits to be derived from aesthetics or recreation except in the rarest of circumstances. On occasion, the threat of litigation of damages provides the necessary incentive for an attempt at restoration of a polluted ground-water resource.

In one of our southern states, an alluvial aquifer was polluted by oil field brines which had seeped from an "evaporation pit." High-capacity wells tapped this aquifer to irrigate extensive rice fields. Due to the low tolerance of rice to salt, the problem was soon discovered--but not until a considerable portion of the aquifer was contaminated. After intensive investigations, it was concluded that under natural gradients it would take approximately 250 years for the aquifer to cleanse itself, and that attempts to artificially restore the aquifer could not be justified. Plans to restore this aquifer included containment, pumping, use of the salt water, and well injection. It would take three years and $200,000 to remove the salt water by pumping with a discharge to a river. Of course, this option was against public policy. Other options required 10 to 17 years for recovery with costs up to $2 million.

If the leachate from a landfill threatens a city's well field, the alternatives include collecting the leachate for treatment or obtaining another source of water. Considering the protracted period over which the leachate would require treatment, the most viable alternative would almost always be the latter.

There is little doubt that our goal should be to protect rather than restore the quality of ground water. It is necessary, however, that some means be developed by which the intrinsic value of ground water can be determined so that this goal can be placed in its proper perspective. The intrinsic value must include the consequences of allowing a valuable resource to be unavailable to us for several generations.

Controlling ground-water pollution necessarily requires rules and regulations and the resources for their enforcement. Some states have excellent personnel and programs directed toward protecting ground water, while others are sadly deficient. The cost to regulatory agencies at all levels of government will be reflected by the personnel, equipment, and program requirements for satisfactory levels of performance. These costs will increase as the level of sophistication increases to meet the complex problems of the future.

Adequate regulations also will impose a financial burden on the public community in terms of increased costs for waste-treatment facilities and, in some cases, improved well construction. Industry also will be expected to properly treat those wastes which now are reaching ground water or to develop an alternate means of disposal. Both municipal and industrial concerns probably will require additional monitoring facilities.

CONCLUSIONS

Our unquestionable goal must be the protection rather than the restoration of ground-water quality. Although this goal will impose an economic impact on both the public and private sectors, it will be meager compared to the alternative of quality restoration. Allowing this resource to be destroyed and unavailable for future generations is conceptually unacceptable.

The problems which threaten ground-water quality can only be prioritized empirically, due to the crippling lack of information on the number of various sources of contamination, the contaminants with which we should be concerned, and the manner by which these move, adsorb, and are degraded in the subsurface environment.

For a workshop dedicated to the development of public policy on ground-water quality protection, it is only fitting to close with some statistics. In January of this year, EPA submitted a report to Congress entitled, Waste Disposal Practices and Their Effects on Ground Water. Some estimates are presented in that document which can guide us in determining the present and future status of our ground-water quality. It is important to note that these estimates are concerned with only a few of nearly two dozen possible sources of ground-water contamination.

The report states that "For every waste-disposal facility documented as a source of contamination, there may be thousands more sited, designed, and operated in a similar manner." The following list presents the estimated leakage to ground water from the most significant waste-disposal practices.

Waste Disposal Practice	Estimated Leakage to Ground Water
Septic Tanks and Cesspools	800 billion gallons per year
Municipal Sewer Systems	250 billion gallons per year
Industrial Treatment Lagoons	100 billion gallons per year
Petroleum Exploration and Development--Pits	43 billion gallons per year
Municipal Treatment Lagoons	18 billion gallons per year

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NON-DEGRADATION AS A GROUND-WATER QUALITY POLICY

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Professional policy choices are hollow statements without public acceptance; that acceptance must rest on a foundation of understanding. Thus before we can form and expect to implement any policy about ground water, particularly a governmental policy, there must exist a clear understanding of the system called ground water. Therein lies the difficulty. As the National Water Well Association's leaflet points out, the general public's understanding of ground water is a realm of myth and misunderstanding; and, unfortunately, most public-policy-makers seem even less erudite. While policy may be exclaimed from academic fact and concept, implementation will rely on popular support and understanding. We need clear concepts packaged in an appealing manner for the education of our several publics. An educated public, knowing some realities of ground water pollution and production, certainly will support a non-degradation policy.

Ground-water theory and technology are rapidly expanding fields, and the horizon presents many challenges. Ground water is a young science and typically some will say we do not know enough yet for a public information effort. They are short-sighted. We are now at the state-of-the-art where we can, and must, immediately assault the challenge of education to bring about public understanding to support ground-water policy. While education may not be a primary goal of most of your organizations, a small investment in education will reap large dividends. All of us here must take the initiative in bringing ground-water understanding to the public.

In this effort, we in ground water must take care that our educational efforts do not create more difficulty for ourselves. Academic distinctions in definitions can be just as damaging as oversimplifications. We must be vigilant that, in our zeal for ground-water understanding, we do not ignore the holistic view that ground water is simply one segment of the hydrologic cycle.

What is non-degradation? Since the utility of ground water is limited both by quality and quantity, we must consider degradation as any negative influence on either characteristic. In the water-abundant East we tend to forget quantity; but we should not, as quality and quantity are interdependent.

We need a non-degradation policy because ground water is an essential natural resource; a resource which has been vital to the establishment of much of

America. The mobility of our society, the dispersal of our industry, and much of our agriculture depend upon a readily available supply of clean ground water. We can no longer consider it a commodity, even an essential commodity. Life as we know it today depends on a dependable, abundant, clean ground-water resource. The future less-energy-intensive, less-mobile society which we are approaching will be even more dependent on that quality of resource.

Many resources today are spoken of in terms of renewability; fortunately, some ground water is renewable. But with ground water, renewability is a matter of time versus demand. Certainly, many ground-water reservoirs can be recharged, but can recharge keep pace with the demand? And, of course, where aquifers are not being naturally recharged, we must switch to management of a finite resource.

But even in static terms, how much are we deluding ourselves when we talk in terms of 90 percent of the world's potable water being ground water? The fact undoubtedly is accurate, and I suspect supplies could support higher than current demand. But I also suspect careful analysis would show a strong analogy to the problems with the currently fashionable promotion of coal to supply a major portion of our energy resources. What are the realities of accessibility, distribution, and quality? Let us look at a few examples.

1. We know we can withdraw water in great quantity from some unconsolidated aquifers, only to find that the aquifers and the surface above collapse, and both are greatly diminished in value.

2. Large quantities of ground water are available in karst areas, but the unique geology yields some of the most valuable agricultural lands in the East. The increasing commercialization and development of these lands is heavily dependent upon this excellent ground-water supply. But can we, as an economy or as a society, continue to develop these lands at the expense of their other natural qualities?

Salt-water intrusion, ground-water mining, and the maintenance of base flow to surface streams are other factors which may limit such promotional dependence upon our ground-water resource.

Quality of this essential resource is the second consideration. But since the program lists other topics which will undoubtedly cover quality problems in great detail, I shall limit myself to several general points.

First, we all recognize that certain aquifers and soil systems have great adsorptive and attenuative capacities with respect to many water pollutants. We depend upon these natural capabilities in many current waste-management schemes. These capacities, however, are parts of natural, dynamic ecosystems. Many of these systems are quite adaptable to stress; but when over-stressed the system breaks down, often with far-reaching, though not always obvious, results. As long as we continue to depend on the resiliency of natural ecosystems to solve some of our waste-management problems, we must develop a better understanding of the full extent of the strain which results in the system. Renewability of the resource loses much of its appeal when the recharge zone is so laden with PCB, PVC, PCP, heavy metals, leachates, and road salts that the resultant resembles alphabet soup.

Second, we often talk about contaminated ground water, but rarely of a contaminated aquifer. Given time, a polluted slug of water may move on to a less accessible or "environmentally safe" place. But certain pollutants, for instance the hydrocarbons, react differently: they tend to have greater affinity for the substrate of the aquifer. They simply sit there imparting their noxious properties to all the water that passes through. Ground-water quality is not simply a matter of water quality, but of aquifer quality as well. We can not expect to deliver potable water through dirty pipes.

Third, in talking of ground water as a natural resource, those of us who come from areas where ground-water quality is naturally high tend to be locked into the concept of "potable ground water for direct human consumption." But, no matter what the ambient quality, there are other instances where the arguments for preservation of ground-water quality still hold. For example, in many areas of the country, maintenance of surface streams, with their attendant fresh-water ecosystems, through the dry season of the year is almost wholly dependent upon ground water. This base-flow discharge maintains stream flows and wetlands which, in turn, maintain a large variety of animal and plant life. Whether the quality of water is potable or highly saline, the local ecosystem has adapted to its natural quality. But we cannot expect it to adapt to seriously contaminated ground water at a time of critical low flow and minimum dilution. In a second example, I understand that currently a small number of industries are using highly saline ground water as a raw material in their processes. In theory, they are no different than the brewery which uses nearly distilled mountain spring water. Neither should have to worry about, nor pay the expense of, cleaning up materials placed in the water supply by some up-gradient user.

Much of the public has long assumed that the ground-water resource is there, clean and potable, ready for their use. Except where local conditions have taught the public otherwise, the general conception is that wherever one wishes, he may drill and find water needing no treatment before domestic use. The occasional "dry hole" and "bad water" strikes do little to change this widely held belief. It forms the core of present public policy on ground water. It will be difficult to displace, and I see no reason to deviate from it. Research, education, and experience may eventually bring the realities of ground-water quality and quantity to the public; but these realities should in no way alter the basic policy. We should treat ground water as we treat any other natural resource: take only what we absolutely need--and do that carefully, foster conservation and resource recovery in the use-cycle, and promote the renewable aspects of the resource.

A policy is but the means of attaining a goal. The goal toward which humanity must strive is to live within the balance of natural systems. The stresses which weather has placed on our life styles in the last several months have done a lot to demonstrate that we are living perilously close to the limits of our resource base. For certain energy and metallic resources, we are at, or should recognize, the approaching "doomsday" phase of development. But ground water is still in the "discovery and promotion" phase. The ground-water industry is faced with opportunity: a chance to learn from the mistakes made in developing and using other resources. We still can plan development and allocation. Most importantly, we can plan for resource maintenance both in quality and quantity. As a goal, the preservation of this resource, which is so valuable to life in all its forms, is not only necessary, but mandatory--if we are at all concerned with the quality of life in the future.

From a social standpoint, a strict policy of non-degradation for ground water speaks directly to a right which all should have--a right to live in a clean environment, hospitable to human life. It should not be necessary to make allowances for, or clean up after, our neighbors' waste. As one tool to implement this, I propose that wherever past or future land practices are inimicable to ground-water quality, a restriction should be placed upon the property deed so that future owners will be forewarned. As a bare minimum, this should apply to the practices of injection wells, land spreading, spray irrigation, and the handling and storage of chemicals and petroleum products. This proposal does not cover the down-gradient movement of pollutants to other properties, or the legal/institutional mechanics of placing the comment in the deed. These details will be difficult, but can be worked out. I am told a second tool is already successful in a few other countries--total mass accountability for all raw materials in industry. All input must be balanced by the products, byproducts, or waste. The economics of such accounting would soon end spillage, dumping, and dispersal of resources. Programs like these will be powerful persuasion to encourage the protection of our ground-water resource until resource recovery is fully operational.

Not too long ago, a New York State legislator, whose county is having great difficulty locating a new landfill, said, "We can't put it in the air; we can't put it in the water; now we can't put it in the ground. What can we do with it?" Many of the proposals to place wastes on the ground or underground are the result of other environmental laws which are keeping the wastes out of other spheres of the environment. We know that by placing them on or in the ground certain wastes will be attenuated, and that some others will be delayed before they are cycled into the biosphere. But the cycle eventually will be completed. A strong non-degradation policy for ground water will be the last of the four basic tools necessary for management of waste in the environment. We have fundamentally good laws for surface water, air, and the oceans. We now must set our sights upon the land and its ground water. This will close the final loophole and begin to move us away from the profligate waste of all natural resources. It will be a major tool to move us from the era of disposal and dispersal of resources to recovery and re-use. Such a policy with respect to ground water will not create any social or economic dislocations other than those already initiated as a result of current environmental and resource-management efforts. It will, however, accelerate social and economic adjustments as this last loophole is closed.

One of the questions which I was asked to address in preparing these comments related to the "trade-offs in damages to the surface environment when a problem solution is shifted underground." The phrasing of this question indicates a basic problem with our current thinking. We can no longer simply shift around temporary problem solutions. We must look toward real solutions. A strong non-degradation ground-water policy is an essential tool in bringing us to those solutions. Because of technological and institutional problems, the ground-water environment will have to accept additional waste for some interim period. Even in this interim, however, a strong ground-water policy will ensure that what must be accepted will impart minimum damage.

LIMITED DEGRADATION AS A GROUND-WATER QUALITY POLICY

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The Connecticut Solid Waste Management program has two primary goals: (1) to protect the environment from the hazards that come from land disposal of our residuals, and (2) to realize and implement the opportunity that recovery of components from the waste stream represents. To be sure, the program has numerous other objectives, but they are secondary to these goals.

To put the Connecticut ground-water policy in perspective, one must understand our waste-management program. Traditionally, three sinks have been used for disposing of wastes: land, air, water. These practices have resulted in environmental degradation, public-health problems, and the depletion of resources. The Connecticut approach to waste management, which is on the way to being accepted as a national policy, is one in which we believe there are values in wastes that society ought to exploit. Not to exploit these values results in missing an economic opportunity as well as failing in our environmental stewardship.

We have recognized that the present systems in use today are, for the most part, inadequate. There is, or has been, an aversion to spending money on a "non-profitable enterprise." Therefore, the first consideration in selecting a method for waste disposal has been that it be inexpensive. But with the quantity of residual wastes that are generated in our society, other criteria have to be considered. These include the pollution problems resulting from use of the three sinks, land, air, and water, and require serious civic and engineering considerations. When one considers the total quantity of waste that is generated in the United States per year, one can appreciate the magnitude of the problem.

Mostly, when people think of waste, they think of it in a negative fashion. It is something bad. It smells bad. It's disgusting. "Get rid of it," we say. This "Get rid of it" philosophy has governed most of our thinking about waste management until very recently. This philosophy is responsible for our current standard practices, for example, of burying and burning solid wastes. "Out of sight, out of mind" has been our basic attitude. "Do as clean a job as you can, but get rid of it."

We are riding a skyrocket, too, in terms of waste production. Per capita waste production is increasing. Since we have an increasing population, you can see how the amount of waste produced is going to increase from both factors. Waste is piling up. Waste will not wait. We have to do something about it.

The key to understanding the basic process that ought to be followed in solid waste control lies in answering the question, "Why waste waste?" We must ask ourselves: "Has all of the utility value of waste been extracted by the first user? Are there no secondhand values that remain?"

Here we need a change in concept and a change in nomenclature. We have to redefine solid waste in order to show that it is a source of some values rather than a source only of problems. We cannot hide our heads in the sand and say there are no problems--but we can view the problems from the positive side, as opportunities. We call solid waste, for example, "under managed resources." These are resources out of favor (because people are generally disgusted with them), out of place (because they are not in a condition or location where they can be productively employed) and out of sequence (because they are falling out at the tail end of the production-consumption cycle, rather than coming in at the beginning of that cycle). Looking at things this way gives them a different aspect. When we consider solid wastes as "under managed resources," we can say: "All right, let's apply management. Let's apply technology." These are things we know how to do.

The result, then, is resources recovery. This is the positive approach to waste control. We process wastes in such a way as to recover materials and energy. We utilize our technological and management know-how to produce valuable materials and products out of garbage, refuse, and junk. And, in the process, we achieve that end which is so diligently pursued by municipal and state governments today: effective waste disposal.

We have always had businesses that are interested in garbage, refuse, and junk. They now recover more than 20 percent of the materials that flow from our forests and mines through our factories, homes, and junk yards.

Although there is value in what is left after they get through, the profit potential is not adequate to be attractive to the private operator. The possibilities of the remainder of the waste stream do not meet the profit performance requirements prevailing in the open marketplace. If we continue to rely on the present system, we will be forced to dispose of far too high a percentage of residuals, and will continue to lose resource values.

This is where government has to step in to harvest the values in wastes on a wholesale basis. This is why, in Connecticut, we are applying technology and management know-how on a regional basis with statewide implications--to achieve "mass production."

Essentially, the philosophy is that by the application of technological know-how and management skills, we can create useful resources and return them to the production cycle. If this is done on a large-scale basis, we can market the useful resources and use the revenues from this marketing to reduce initial costs. We can obtain the value of having the opportunity to create added social values in terms of environmental enhancement, economic growth, protection of the resources bank, and decreased negative land use, to name a few.

However, in the Connecticut system or in any future state system that will develop as an outgrowth of the Resource Conservation and Recovery Act of 1976, there will always be a need for well designed and operated land-disposal areas to handle that portion of the waste stream that is not processable by resource-recovery systems, to handle the residue generated by the system, and for use when the system has a breakdown. So let it be clear that land as a sink is a most important tool in waste management and will be part of any management system for a long time.

The significant question then becomes, "How do we effectively establish a policy that deals with placing residuals on land?" Any such policy must recognize the environmental considerations, the public health implications, and the need to dispose of these materials, as we must. It also must recognize that disposal is going to take place on the land. Interestingly enough, in the Third Report to Congress on Waste Disposal Practices and Their Effect on Ground Water, which was issued by EPA in April, 1976, the agency concludes that "there are some real research needs that must be satisfied to facilitate a viable program of groundwater protection." The EPA report goes on to summarize that:

-- More data are needed on acute and chronic health effects from contact with the various contaminants found in ground water.

-- Better criteria are required for site selection based on the interaction of geology, hydrology, soils, climate, attenuation, and waste characteristics.

-- More emphasis must be placed on determining the importance of previously ignored problems, such as sewer exfiltration and mine-waste disposal.

-- Research is required on how to control contamination from existing waste-disposal sites.

I have no disagreement with that summarization; in fact, I heartily endorse it. However, while action proceeds on these matters in the various EPA offices, we at the state level of government have to deal with how best to dispose of these residuals today and tomorrow.

It is our best judgment that, in dealing with the placement of residuals on the land, the only approach one can take is based on a policy of limited degradation. To follow any other policy would lead us to conclude that (a) no residuals will be placed on the land, which is absurd, or that (b) we can design, operate, and guarantee land-disposal facilities that will provide "zero discharge," which also represents a nonrealistic attitude.

In Connecticut, we accept as a given that each disposal area will leach. We further accept the fact that, at present, reliable technology for collecting and treating leachates so as to render them harmless over the long term simply does not exist. Those two givens helped us to come to grips with a limited degradation policy. Since there is really not enough data available to develop a workable standard on all the various contaminants from residuals that may end up in ground water, it is impossible to determine a standard discharge in terms of a number. That makes it very difficult for the layman, the non-technical public official, and the non-technical elected official to deal with essentially a non-standard. The only viable way to determine locations for disposal areas is on a case-by-case basis. Simply put, each individual, new source of contamination will be evaluated on its own merits to limit the amount of degradation to water. In doing that, it is critical to have proper site selection, which is based on the ability of the soil to work as a waste-treatment system, because the soil will bear the burden of waste disposal, and, of course, to make sure that the proposed site is not located in an area of existing or potential ground water use. That is a tall order, one that requires a great deal of study and analysis before a decision is made. That decision, which is technical in nature, also becomes--for all practical purposes--a land-use decision. One must recognize that the residual must be disposed of and that, in certain cases, the decision might be made to write off a portion of ground water or an aquifer as a sink for disposal. I do not suggest that it is proper in every case, but it is a possibility that one must contemplate when considering a policy of limited degradation.

The next question one begins to deal with when discussing a limited degradation policy is that of risk taking. Quite frankly, there are risks. For many years, no thought was given to any of these considerations when deciding the location of disposal facilities, so risks and costs were not factored in. But now we know better. We must admit that, with respect to the processes of locating these facilities, we are in an evolutionary period. That means there are going to be risks, and they must be taken. The old cliche about sending a man to the moon is appropriate, because that was the government taking risks, riding the heat, and making some mistakes. But the very process of taking action, the very process of making a change, the very process of solving a problem means that some risks are involved. To some extent, I think, the risks involved with limited degradation policy can be identified and minimized. Much depends on the individual contaminant being dealt with and how well its environmental chemistry is understood. And that gets back to the research suggested by EPA in its report to Congress. For example, we know salt will do whatever it pleases when placed on the ground, so one does not readily place a pile of salt next to a well. Even in the absence of understanding the chemistry of all potential contaminants, we can identify the flow of the ground water and what it is likely to contaminate, and then make some reasonable decision as to how much contamination there may be and whether or not we can accept that amount of degradation. We are comfortable with sending the contaminated water into a high-dilution receiving body, so as to minimize the potential pollution--after, of course, it passes through the proper soils for natural cleansing.

Along with risks, costs also must be considered. There are economic costs and there are social costs that can be attributed to all public policies. There are instances where improperly placed land-disposal facilities have contaminated water supplies, and the economic costs for replacing those water supplies ranged from the hundreds of thousands to the millions of dollars. In addition, there are the social costs, the impact on peoples lives, that have never really been quantified. However, with a policy of limited degradation, the economic and social costs should be negligible. For this reason, limited degradation is the recognition of pollution. I have earlier alluded to how we deal with making the determination as to siting such a facility. When we make that determination, we know that the proper geo-technical evaluation and socio/political evaluation has already been made. In short, when a community determines that it would like to locate such a facility, it already has factored in the political/social ramifications of that decision, which is a land-use decision. Our judgment, relative to the degradation, would only allow us to approve a facility that should have a limited impact and in turn would result in negligible economic costs. I believe that we have become technically sophisticated enough so as to preclude making a decision which might contaminate a viable water supply.

In conclusion, we must recognize in materials that need to be disposed of, the presence of substances that will contaminate the ground water. We also must consider that there are unknown substances in this category which will exist in leachate. Connecticut, a leader in resources recovery, readily acknowledges that total recycle or reuse of many residuals is not a presently available technological alternative to an obvious need to dispose of such materials; consequently, land disposal is the practical alternative which must be employed to fulfill the need. The problem facing the public decisionmaker is to find an acceptable location for the disposal. The problem is not to establish in absolute terms that no water will be contacted by pollutants, for that would be impossible. Rather it is to establish with reasonable certainty that no water which is contacted by pollutants will be significantly altered to preclude existing or reasonable anticipated use by persons or to interfere with the physical, chemical or biological integrity of waters in direct contact with living organisms. In my judgment, that attitude should be impressed into public policy. The interpretation of that policy is very clearly that of limited degradation. Anything short of that just is not facing the realities of where we are in terms of the need for land disposal and where we are in terms of new technology to deal with the residual problem.

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Policy Regarding Sources of Contamination

SURFACE AND SUBSURFACE MINING:

POLICY IMPLICATIONS

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PENNSYLVANIA MINING POLICY

Pennsylvania's existing policy on ground-water protection with respect to surface and subsurface mining requires that an operator must make every effort to prevent pollution to the ground water and surface water. All discharges from an operation must meet the water-quality criteria of streams before they can be discharged. If a discharge does not meet these standards, it must be treated to meet the standards' criteria. Surface coal mines are not allowed to accumulate water in the pit area. To meet this requirement, diversion ditches are constructed above the high wall of the operation to divert the surface water away from the pit. Any accumulations in the pit are pumped out and treated.

Following the completion of mining, the acid-bearing material must be placed below the water table. If the mine is in an area of a fluctuating water table, the acid-bearing material is placed above the water table and covered. It is then recommended that an amount of lime be placed in the backfill areas above the acid-bearing material. Then, as the shallow ground water percolates through the backfilled material, it leaches out alkaline $CaCo_3$ into a solute which mixes with the acid. This is the reverse of an often-used method of placing the acid material above or ahead of limestone, which became coated with ferrous iron.

The restoration process is completed with the replacement of topsoil and seeding with grasses. Grasses do provide alkalinity in the soils and produce a quick cover to prevent erosion.

The effect of underground mining is almost totally different. In Pennsylvania, underground mining sometimes occurs below the ground water, as in extracting Pittsburgh Coal in the southwestern part of the state. It also may occur above and below the water table, as in mining the Allegheny Series coals, or above the water table but interconnected with perched water tables. Where mining occurs below the water table, the mines must be dewatered. This ground water is treated before discharge, if needed. Some underground mines can discharge their effluent without treatment if the ground water is moved out of the mine quickly enough. This is possible if the mine water does not have contact time with acid material.

Mines which cross the water table are dry until the water table is encountered. However, most of these mines must treat the ground water prior to removal. The same is true with most mines interconnected with perched water tables.

Once mining is completed, openings which are developed to allow ground water to discharge by gravity flow make it nearly impossible to seal or change the flow of ground water. That is the reason we propose mining to the downdip. This usually keeps the ground-water movement in the same flow paths as it was prior to mining.

It is difficult to mine for any mineral without affecting water quality and quantity. Only by employing methods which reduce the probable damage to ground water by mining can quality be recovered at a slightly lower water table.

POLICY BASIS

Existing Pennsylvania policies are based on the Clean Streams Law and the Surface Mining Conservation and Reclamation Act. These laws are also supported by rules and regulations. Underground mines and surface mines also are covered by state and federal safety laws and regulations.

The primary reason for passage of these laws was to prevent pollution of the state's streams due to acid mine drainages from underground and surface coal mines. Prior to 1965, underground mines were sealed for safety reasons, but this did not restrict the acid flows. Surface coal mines had discharges also, because methods of reclamation were non-existent until 1945. In that year the legislature enacted the Bituminous Coal Open Pit Mining Conservation Act, which required open-pit coal operators to carry out reclamation. Changes in the law between 1945 and 1963 provided for backfilling, grading of spoils, and the planting of trees, shrubs, or grasses. Prior to changes in the law in 1963, these pits became small ponds or lakes of acid which seeped through the spoils or discharged to the streams by headward erosion. In 1963, operators were required to post performance bonds to comply with the provisions of the Open Pit Act. The performance bonds could be released only after the operator met with the backfilling and reclamation conditions. By 1967, backfilling to approximate contour and a Mine Reclamation Fund were provided by law for both anthracite and bituminous open-pit mines. The funds for both anthracite and bituminous open-pit mines were developed through license fees, forfeiture of bonds, and securities or cash deposits.

In 1971, the Surface Mining Conservation and Reclamation Act was passed to replace the bituminous open-pit law. With minor exceptions, this act covered all forms of surface mining. One exception is for the landowner who uses his own land to develop non-coal minerals for non-commercial purposes or leases his land "for the extraction of such non-coal minerals for commercial purposes in an amount less than five hundred tons per acre of aggregate or mass of mineral matter in any given year."[1] It also excludes mineral for borrow pits for highway construction purposes if the work is under bond, contract, and specifications which provide for reclamation of the area and the handling, processing, or storage of slag if located on a manufacturer's premise as part of the manufacturing process.

Although the Clean Streams Law had been on the legislative books since 1937, it was not until an amendment in 1945 to this act that mining was covered. This Clean Streams Law states that it is:

> ". . . an act to preserve and improve the purity of the waters of the Commonwealth for the protection of public health, animal and aquatic life, and for industrial consumption, and recreation; empowering and directing the creation of indebtedness or the issuing of non-debt revenue bonds by political subdivisions to provide works to abate pollution; providing protection of water supply; providing for the jurisdiction of courts in the enforcement thereof; providing additional remedies for abating pollution of waters; imposing certain penalties, repealing certain acts; regulating discharges of sewage and industrial wastes; regulating the operation of mines; and placing responsibilities upon landowners and land occupiers."2

After 1945, all mine operators were supposed only to file for a permit. For mines which had acid water, operators could discharge to acid streams but not to designated clean streams. In 1949, it was established that acid discharges should not exceed alkalinity and should not contain objectionable amounts of iron. By 1951, it was recognized that surface-water flows must be diverted away from surface mines by ditches. Then the Sanitary Water Board adopted rules and regulations concerned with the disposal of acid-forming refuse from strip mines. In 1964, the strongest backfilling law in the United States went into effect. This became a major contribution to the control of pollution from surface mines which produce acid drainage. This change came about through the normal progression of observation and study but, like many great advances, it was triggered by a catastrophe. That event was the pollution of Slippery Rock Creek in northwestern Pennsylvania. The man who pulled that trigger was William E. (Bill) Guckert, present Bureau Director of Surface Mine Reclamation. Later he became one of the architects in the change of the Clean Streams Law in 1965. Changes in the Clean Streams Law affected the underground mines more significantly in that, before any coal mine could be opened, reopened, or continued, the mine operator had to submit an application with a proposed drainage and waste-disposal plan. This meant all underground mines, surface coal mines, and their associated cleaning plants had to have approved permits to operate. By 1970, the legislature ruled that underground mines must be sealed watertight upon closure. Later, two major legal decisions, Harmar-Hutchinson and Barnes and Tucker, were legal milestones in dealing with ground water and underground mining. These U.S. Supreme Court decisions stated that an operating mine was responsible for all acid mine drainage into Pennsylvania waterways, including mine drainage from abandoned mines.

Present attempts to change Pennsylvania policies are directed at closing the gaps of the unknown needed to provide protection to the waters of the Commonwealth, and at coexisting with good mining practices. It is my personal feeling that we can and must have this coexistence.

GROUND-WATER QUALITY CONSIDERATIONS

Because any type of mining can and does affect the ground water, it is difficult to pinpoint the extent to which existing policy takes into consideration the impact on ground-water quality. First, ground water throughout most mining areas in Pennsylvania is under water table conditions, as opposed to artesian conditions. The state also has a discontinuous aquifer system, not a continuous system as is often found in other areas of the country, so ground-water studies are difficult. Perched water table conditions add further complications. The areal extent in either case is limited by the depositional environment. These ground waters are often associated with the coals. There has not been a program in Pennsylvania to ascertain the ground-water quality throughout the state, except in the case of municipal public supplies. Other ground-water data is limited.

It appears to me that before a policy can consider the impact (total or partial) of mining on ground water, it is necessary to know the general water quality and the coal stratigraphy as it relates to these discontinuous aquifers. The state's coal petrologist-stratigrapher is busy mapping the coals of Pennsylvania. He is finding that only the Pittsburgh Coal lies in a horizontal deposit, and that most other coals appear to be deposited more like a strand line of coastal areas of the continent.

However, despite our handicaps, we do take samples in mining areas to determine the water quality of the area to be mined. This gives us some knowledge of the quality. The problem of maintaining water quality around mines is caused by the exposure of the acid-bearing material to the atmosphere and the leaching of flowing ground water. Iron and sulphates are leached out and form the sulphuric acids, which are transported to the streams by surface drainage and ground water. Shales, associated with the coals, weather and produce a fine-grained alumina sediment which coats the bottoms of the streams. The present methods used by Pennsylvania surface-mining operators have, in most cases, restored ground-water quality to the site.

The Bureau of Surface Mine Reclamation is conducting a study to attempt to determine the types of pyrite present in the overburden. It is the Commonwealth's intent to be able to identify the nature of pyrites in the overburden or associated with the coals. This should help us make decisions about mining in the bituminous coal fields where potential pollution may exist. The study also is to determine pre-mining, mining, and post-mining conditions. This data will be used to guide further work and permit application reviews.

If the bureau's program is successful, similar attempts will be made in the anthracite fields. To help assure the program's study efforts, interim stream regulations have been proposed and presented to the Environmental Quality Board for adoption.

In the anthracite field, it is difficult to determine the impact on ground water. Pennsylvania is living with problems created 150 years ago and complicated by the complex, plumbing-like interconnection of surface and underground mining. The complex geology and ground-water conditions are not totally understood because most of the mining occurred before the geology was worked out to present-day levels of sophistication. The mines lay in several synclinal basins. Surface drainage is almost non-existent and the subsurface mines control ground-water flows through a maze of tunnels which interconnect these mines. The drainage reaches streams via flows to outfalls strategically located at the lowest surface levels of the basins. Some basins are interconnected by tunnels capturing flows which divert the ground water from one basin to another. The correction of this problem has staggered many expert mining engineers and geologists.

In non-coal mining, such as quarries, impact is a lesser problem. Ground-water quality is rarely more of a problem than sedimentation. Dewatering becomes a more potent problem. This is especially true with underground mining. Underground mining of all minerals presents more ground-water quality and quantity problems than surface mining. The effects of dewatering are difficult to assess. Many complaints from citizens are filed because of suspected or real dewatering. However, with ground-water quantity studies, the problem could be eased.

FILLING INFORMATION GAPS

It is my opinion that unless the quality and quantity of the ground water is known, we can only guess about the amount of damage to ground water resulting from mining. It has been my experience over the past 10 years that citizens who complain about damage to water wells and springs have great difficulty getting satisfaction from any action taken on their behalf. The reason for this is that the average citizen has no documented evidence of ground-water quality or quantity. When the Commonwealth acts on complaints from citizens, it finds it difficult to justify pollution of wells or springs if there is no sample from the water source prior to the complaint. Directions of ground-water flow cannot be accurate in Pennsylvania unless a hydrologic study is made. This is not necessarily true in areas where the extent of aquifers is known.

If the ground-water hydrology is well defined, as it is in some states, then the source of pollution is usually not well defined in many mining areas. The sources of pollution from mining will vary as widely as does the geology of this country. To determine the nature of the pollution resulting from mining, geochemical studies, such as the Bureau of Surface Mine Reclamation in Pennsylvania is doing, will need to be conducted.

Mining does change the environment. However, the coal industry is learning that good reclamation practices can stabilize some of these changes without serious damage to the ground water. There should be compatibility between mining and the environment. That compatibility must be found to achieve a national policy.

Additional ground-water information also is needed concerning barrier thickness and stability, multi-seam coal mining, synclinal basin dewatering, and new techniques of mining. Then in complex geologic areas, similar to the broadtop and the anthracite areas of Pennsylvania, a better understanding of the hydrology would enable us to modify present and future methods of mining to reduce water pollution. This is especially true if coal is to be the backbone of the country's energy supply.

A brief synopsis is necessary to show why these problems are considered gaps. Presently in Pennsylvania, coal barrier thickness is considered a function of safety only. The criteria, as stated in the bituminous safety manual, is "a barrier pillar, from the operation to the property boundary line, of not less than ten feet plus two feet for every foot or part of a foot of thickness of the bed measured from the roof to the floor, plus five feet for each one hundred feet or part of one hundred feet of cover over the bed at the boundary line."[3] Since enactment of the Clean Streams Law and the change of philosophy about methods of underground mining, the strength of the barrier and the reduction of ground-water flow must be determined. This is not difficult to understand if one can picture sealing an underground mine with a seal engineered to withstand a substantial hydraulic pressure, but in which the natural walls of the mine between the interior and the surface are 50 feet or less.

Multi-seam mining problems are related to those areas where underground mining occurs on several coals but during different mining eras. Early mining started in the best quality, easiest-to-mine coals. Also, mining was conducted to allow gravity flows. Often these are high-volume, high-iron, and very acid flows. Present mining operations are left with the more difficult-to-mine coals and more marginal economic production. If mining is conducted in areas where coals are less economically produced and difficult to obtain, these coals usually overlie old, discharging underground mines. Coal production in these areas will increase the volume of ground water and increase the risk of pollution flowing from the old mines. Synclinal basin dewatering has many technical ground-water problems and a few legal problems.

As an example of technical ground-water concepts needed with new techniques of mining, consider mountain-top removal in surface mining. Present laws control most surface mining and control is considered on a case-by-case study. However, we have had only one proposal for such mining. We have not experienced such a technique of mining to date, but we must completely review the mining concept to determine what effects it will have on the particular area.

This type of mining employs the use of very large machinery which would lift three or four coals from a large tract of land. This would physically disturb the present stream locations and open larger cuts which present sedimentation and erosion problems. It would lower water tables, change the chemical and biological character of the streams, and cause relocation of some highways. In Pennsylvania, the company would be required to backfill as it progresses with the mining. If the operation affected flowing streams the operator would be required to get permits from the Division of Dams and Encroachments. This means filing an acceptable plan with that Division. Moving roads requires permission from the Department of Transportation, township, and borough governments. It is our technical opinion that, although the water table would be lowered during mining, it will return to a somewhat subdued level below the present water level following the backfilling.

The change in the chemical and biological character of the stream would make it most difficult to predict what recovery problems would occur. To answer this problem we would need more information.

FOOTNOTES

1. Surface Mining Conservation and Reclamation Act, Department of Environmental Resources, Bureau of Land Protection and Reclamation, Division of Mine Reclamation, 1971, Act 355, Sec. 3, p. 1.

2. The Clean Streams Law of Pennsylvania, Including All Amendments, Commonwealth of Pennsylvania, Department of Environmental Resources, 1970, Act 394, p. ii.

3. Bituminous Coal Mining Laws of Pennsylvania for Underground Mines, Department of Environmental Resources, 1961, p. 114.

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Chronology of Milestones, Pennsylvania's Clean Streams Program and Addendums, Commonwealth of Pennsylvania Department of Environmental Resources, Bureau of Water Quality Management, 1905-1975.

Final Report of the Pennsylvania Sanitary Water Board, Pennsylvania Department of Environmental Resources, Bureau of Water Quality Management, Publication Number 29, 1923-1971.

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A Guide for Revegetating Bituminous Strip-Mine Spoils in Pennsylvania, 1965 (Revised 1971).

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The Clean Streams Law of Pennsylvania and Related Statutes, Sanitary Water Board Department of Health, Commonwealth of Pennsylvania, 1966.

The Clean Streams Law of Pennsylvania, Including All Amendments, Commonwealth of Pennsylvania, Department of Environmental Resources, 1970.

Surface Mining Conservation and Reclamation Act, Department of Environmental Resources, Bureau of Land Protection and Reclamation, Division of Mine Reclamation, 1971.

DISCUSSION

In response to questions from the audience concerning the economics of bonding as required by the State of Pennsylvania when it issues a mining permit, Mr. Thompson commented that the state generally requires between $500/acre and $1,000/acre be put up as bond. Forfeiture rate has been less than two percent. If the state has to step in to rectify problems, Mr. Thompson says it may cost four times what it would cost the operator.

Although the average per-acre cost of reclamation is slightly less than $500, the cost of reclamation should have little impact on coal economics because reclamation increases the value of land. Also, Mr. Thompson estimates that approximately 95 percent of the acid drainage problem is being eliminated by reclamation practices.

In response to a question on definition of discharge, Mr. Thompson stated that underground seepage is considered discharge. However, it is difficult to prove contamination is due to underground mine drainage and hold the operator responsible for it.

ABANDONED WELLS, INJECTION WELLS, AND SALTWATER INJECTION: POLICY IMPLICATIONS

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My comments here relate only to Texas policy, and should not be construed to imply that Texas policy should be national policy. In saying that, I am reminded of a sign which a colleague of mine in New Mexico used to have hanging in his office. It read: "I Don't Give a Damn How Texas Does It." It may be appropriate, however, to share something else with you. I say this because--in addition to the Dallas Cowboys, Dr. Pepper, the Alamo, and Jayne Mansfield--Texas has most recently given to the nation the "Gonzales Amendment" to the Safe Drinking Water Act.

Subsurface injection of aqueous wastes has existed in Texas for over 40 years. The first major project was probably an East Texas oil field cooperation project around 1938 which involved the injection of produced salt water back into the oil producing zone. Isolated, single-well injection operations are reported to have existed 10 years before this.

The Texas Railroad Commission (TRC), the state oil and gas regulatory agency, began regulating these operations during the 1940's. With the success of injecting produced salt water, a few chemical plants began looking at subsurface injection as a method of disposing of industrial waste. By 1960, a half-dozen such wells had begun operation.

In order to assure the protection of ground water from the injection of wastes into the subsurface through disposal wells, the Texas legislature, in 1961, enacted the Injection Well Act, which was later amended as the Disposal Well Act and codified in the Texas Water Code. This statute prescribes the permitting system for subsurface disposal of industrial and municipal wastes and produced salt water in Texas.

In accordance with the Act, injection of industrial and municipal wastes into subsurface strata is regulated by the Texas Water Quality Board (TWQB) and the Texas Railroad Commission, with the latter being responsible for wastes resulting from oil and gas drilling or producing activities. Before a permit is issued by the commission for subsurface disposal of produced salt water, an evaluation by the TWQB staff is made to assess ground-water implications.

The Act requires a letter from the TWQB stating that injection is not into freshwater strata and will not endanger underground water resources. The ground-water protection evaluation includes:

1. Adequacy of surface casing and cementing. Water of 3,000 ppm Total Dissolved Solids or less should be protected by cemented surface casing, or equivalent.

2. Adequacy of separation between the top of the injection interval and the base of usable water strata.

3. Adequacy of cement above the injection zone to confine the injected salt water to the zone of injection.

Procedures for obtaining a saltwater disposal permit are contained in Rule 8 of the TRC's Rules of Statewide Applicability.

Subsurface disposal of all other wastes is regulated by the TWQB. A thorough engineering and geological evaluation is made of the waste character, well design, construction, operation and monitoring program. Certain of the drilling and completion phases are witnessed by the board's technical staff.

The TWQB, in administering its responsibilities under the Act, believes that subsurface injection is a practical and feasible method of disposal of certain waste when the overall project is properly designed, constructed, operated, and monitored.

State law allows injection only if:

1. The installation is in the public interest,

2. No existing rights will be impaired, and

3. With proper safeguards, both ground and surface fresh waters can be adequately protected from pollution.

The board recognizes that the subsurface, even in Texas, has certain volume limitations, and therefore, as waste-treatment technology has increased, unnecessary injection is being restrained. It is a general policy of the TWQB to permit injection only after all reasonable alternative methods have been evaluated and found to be less desirable in terms of environmental protection and dependability.

The state legislature gave the TWQB broad powers by stating in the Texas Water Code: "The Board and the Commission shall require any information it considers necessary to discharge its duties." In implementing its responsibility, the board has developed general permit requirements and outlines of fundamental information required to evaluate a disposal well application. This approach requires a technical staff with the expertise to evaluate properly the applications and to stay abreast of current developments so that the best practical technology may be employed. As a result of this policy, construction standards, operating, and monitoring procedures have improved throughout the years as technology has increased.

A detailed technical report must accompany an application including information on the following:

1. An accurate plat showing location of proposed injection well relative to both state land survey and plant boundaries.

2. A map indicating location and depth of water wells on and adjacent to plant property. This map or a supplementary map must show location of all artificial penetrations (oil and gas wells, exploratory tests, etc.) of the uppermost proposed injection interval(s) within two and one-half miles of the injection well site.

3. Description of local topography and geology pertinent to injection program. Depth of deepest strata containing fresh water or water of suitable quality for potential beneficial development as determined by well development and/or electrical logs.

4. A detailed description of the chemical and physical characteristics of the waste to be injected.

5. The anticipated average and maximum rate of injection in gallons per minute. Estimated yearly volume of injected waste and anticipated life of project.

6. Data on drilling, completion and operation of proposed injection well.

7. Characteristics of injection interval(s).

8. Compatibility of injected waste and formation fluids.

9. Calculated formation pressure increase by injected waste and directions of dispersion.

10. Surface installations.

Prior to issuance of a permit, an on-site inspection of the proposed well is made. Also, an additional three inspections will usually be conducted during drilling and completion of a waste disposal well, including:

1. Logging of surface hole and running and cementing of the surface casing,

2. The running and cementing of the long string or protection casing, and

3. Setting of tubing and packer and witnessing testing of the well.

Routine inspections are conducted of permitted operations and any other inspections required to gain compliance with permit terms, and for consultation on disposal-well operational problems, inspections of work-over operations, and plug-to-abandon operations.

In addition to regular field surveillance, each operator must report regularly on operational and monitoring information. Each permittee must keep complete and accurate records of all monitoring required in the permit including:

1. Continuous records of surface injection pressures;
2. Continuous records of tubing-long string annulus pressures;
3. Records of volume injected;
4. Continuous records of injection rates; and
5. All periodic well tests including:
    a. Water analyses,
    b. Measured or calculated bottom-hole pressure readings of the injection zone, and
    c. Well conditions.

Key factors which must be considered in an injection well project are the safe abandonment of it and its effect upon improperly plugged and abandoned wells in the area of the disposal well.

Plugging and abandoning of exploratory and producing wells are common occurrences in the oil and gas industry where hundreds of "dry" holes are plugged each year. While it is not a matter to be taken lightly, the plug-to-abandon operation has become routine business with drillers, oil operators, and cement companies. Certain regulations concerning the plugging of oil and gas wells in Texas have been established by the commission, and requirements for waste disposal wells are under the jurisdiction of the TWQB, whereby an application to plug and a final report must be filed and approved.

In the event a permit is cancelled, or if the well is abandoned, the permittee must submit plans for the plugging and abandonment of the well for approval. The reason for the importance of a properly plugged well is to insure that injected wastes are confined to the zone of injection and also to prevent upward movement of saline formation fluids.

Injection of waste into a disposal formation can cause an increase in reservoir pressure to the extent that the fluid level will rise so that native formation brines or injected wastes can migrate into overlying fresh water aquifers by way of the unplugged wellbore serving as a conduit. In addition, oil or gas producing formations can be damaged due to communication with other fluids.

In abandoning a waste disposal well, the objective is to seal off the waste which has been injected in order for it to stay confined to the disposal zone. This means proper placement of cement plugs: above the injection zone, across any oil and gas producing formation, across the bottom of the surface casing, and at the top of the casing. The cement requirement for capping and abandoning is to cut off all strings of casing three feet below ground level and weld a steel plate on top. However, revisions now underway to rules regarding industrial waste disposal wells will consider adopting a requirement that they be permanently marked by a plaque or monument noting pertinent data regarding the abandoned well.

Since the first waste disposal well permit was issued in Texas in 1961, a total of 132 permits have been issued for industrial and municipal injection wells. Nearly 40 billion gallons of waste have been disposed of into these wells with no known contamination of fresh or usable quality ground water.

Underground injection of liquid waste is by no means an exact science since few, if any of us, are able to see with our eyes many feet below the surface of the ground. We do have tools and instruments available to allow us to interpret the otherwise unknown.

Sufficient knowledge is available that, with proper safeguards, subsurface injection is an environmentally sound method of disposal of man-made waste because the waste can be isolated from man's water, air, and food. Continued research by universities, industries, and regulatory agencies should refine the growing body of knowledge regarding this disposal method.

DISCUSSION

In response to a question on the Texas policy for relying on monitoring of the injection pressures to indicate whether the system is operating as predicted, Mr. Mullican stated that they sometimes require a monitor well within the injection zone. Generally, they rely on the data acquired during the drilling and testing of the well to calculate the effects on aquifer pressures and the spread of the wastes. They do not see any value in monitoring freshwater zones with special monitor wells.

In clarifying his definition of monitoring, Mr. Mullican includes monitoring of the injection zone through specially constructed off-set wells, monitoring of any water wells existing nearby, and monitoring of injection pressures and annulus pressures within the injection well.

In assessing whether injection is the best alternative, treatability studies are made to determine whether injection provides the best safeguard to the environment. The economic differential in determining whether injection is the best alternative is decided on a case-by-case basis. Generally, the economic differential is substantial.

In Texas, ownership of subsurface space (subsurface trespass) is a legal issue. Courts have not upheld trespass from migration of waste across property lines. Nevertheless, effects of existing rights are considered when granting a permit.

OIL WELL OPERATION/MAINTENANCE AND SALTWATER INTRUSION: POLICY IMPLICATIONS

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Our primary water pollutants in oil well operation and maintenance are oil and salt water. The industry produces about 8 million barrels of crude oil per day. This does not include 1.9 million barrels of natural gas liquid. With the crude, we estimate that the industry produces over 30 million barrels of salt water daily. The following are general statements of existing laws and regulations on ground-water quality protection which impact on the industry because policies vary somewhat from state to state.

In the operation of oil wells, drilling is a temporary but very important operation. Whenever control measures are a necessary part of a well site development, a control plan is included in an environmental impact assessment plan which is required in certain states. This plan, included with the permit to drill the well, is necessary if more than a few acres of land are disturbed or if the well site is within a certain number of feet from a lake or stream. The plan is to prevent accelerated soil erosion and sedimentation and oil and waste water spills into streams while the well is drilled. Prevention is accomplished by installing dikes or pits around the drilling equipment. If the oil well is a producer, waste materials and discharges resulting from wellhead leaks or well-servicing operations are controlled or confined and promptly cleaned up. If the well is a dry hole, then the well site is cleaned up of all materials, graded and stabilized by seeding with grass and restored, as far as practical, to conditions compatible with existing land use.

When wells are drilled with air or foam using fresh water as the drilling medium, the medium is not circulated back into the well bore during drilling but retained in earthern pits. Wells are also drilled with fluid consisting of fresh or salt water. Additives are added to these waters to obtain certain properties so that it becomes a drilling mud. The fluid is circulated back into the well bore during drilling by using mud pits and an earthern reserve pit.

Depending upon soil conditions, earthern pits are used. If these pits indicate leakage, then the pits are lined with an impervious material to eliminate leakage. This material can be gel and polymer and/or a plastic pit liner. Also steel pits are used at times. The earthern pits are inspected regularly by state personnel during drilling operations. When necessary for the protection of livestock and/or wildlife, a temporary fence will be constructed to enclose the pits. The disposal of fluid from surface pits is by evaporation, by pumping into the well annulus between the surface fresh water string and intermediate or production casing string, by injecting into a salt water disposal well, by burying the drilling fluid in narrow trenches with adequate backfill, and/or by spreading the drilling fluid over a designated surface area and, after the fluid has dried, plowing or discing it into the ground.

If a large volume of water is encountered while drilling and the drilling medium is air or foam, the discharged water flows into a series of pits. Defoamer is added to break down the foam while solids are allowed to settle out in the pits. Then it is discharged into the stream but only after acceptable chemical analysis has been approved by a state inspector. If we cannot discharge the water into the stream, then fluid drilling is used to contain the flow of water into its reservoir or a string of casing is set to shut off the water. Both of these methods add considerable cost to the well.

Drilling operations must have a SPCC Plan (Spill Prevention Control and Countermeasures Plan) which is required by the EPA. These plans specify that dikes or containment devices be built around fuel tanks. Waste oil from equipment must be collected by ditches and dikes. Pits must be constructed to contain spills from the well. Materials such as straw, sawdust, sand, form pads, and emulsifiers must be available to clean up spills. Blow-out preventers must be on the well while drilling through possible oil and gas horizons to control hydrocarbons if they come to the surface.

The casing program for wells consists of a surface string of casing set from 30 to 100 feet below the deepest fresh water horizon, this being the deepest horizon which will replenish itself and from which fresh or useable water for household, domestic, agricultural, or public use may be economically or feasibly recovered. The volume of cement needed for the casing string is calculated by using approved engineering methods to assure the return of the cement to the surface. In the event cement does not return to the surface, every reasonable attempt is made to fill the annular space by introducing cement from the surface on the outside of the casing string. If a fresh water well is within 200 feet of an oil well, additional approval must be obtained from both the state and the landowner before commencing operations.

Depending upon well conditions, an intermediate string of casing may be set (at about 1,800 feet). This is usually cemented to the surface in conformity with the prescribed procedure mentioned above. This is considered a freshwater string and protects the freshwater horizons. As the well is being drilled and prior to running casing, there is no problem with contamination between the freshwater and saltwater zones. If the well is drilled with fluid, there is not enough overbalance of the hydrostatic column to have saltwater intrusion into the freshwater horizon. If the well is drilled with air or foam, the fresh water enters the well bore and there is no intrusion into the freshwater horizon. Each oil, gas, salt, or freshwater stratum above the producing horizon is cased and sealed off with cement to prevent the migration between strata. Caution is exercised during all drilling operations to prevent rupture of casing. The producing well is equipped with appropriate tubular goods designed to minimize the risk of loss of well control and possible contamination of freshwater sands. Any known mineral deposit, such as coal, is cased off and cemented across the zone to prevent migration of fluids to or from the mineral zones into freshwater horizons.

Our tank batteries and waterflood plants have overflow and backwash facilities. When these facilities must be used, our products of oil and water flow into a pit in which a reinforced plastic liner is installed to prevent leakage of the fluid into the ground. Depending on ground terrain, a drain line is sometimes installed below the pit to monitor any leakage of fluid. In areas where earthern pits are used, yearly inspections and permit renewals are required by the state. These pits are used only in emergencies. No brine is allowed to enter freshwater streams. The disposal is by evaporation or use of saltwater disposal wells or water-injection wells. Secondary recovery projects use injected water to recover additional oil. The saltwater disposal wells and secondary recovery projects require permits from the state. A portion of brine in offshore areas is dumped into the ocean water, a procedure which requires state and federal permits. In the Rocky Mountain area, the water produced with oil often has a very low dissolved solids content and is useful for livestock or wildlife. This water is dumped into streams under state permits. The oil content of all water dumped into surface waters is rigidly controlled. It cannot cause a sheen and is ordinarily below 50 ppm. Tanks, pipelines, and facilities are constructed of appropriate materials to handle some corrosive fluid. When corrosion problems are anticipated, a corrosion abatement program is utilized to minimize the potential for leaks.

Because oil is the product we sell, we have always tried to keep it in a tank or pipeline. Our desire to keep it out of the environment was strengthened in 1973 by the Environmental Protection Agency's SPCC Plan requirement. Now, when an oil spill reaches fresh water because of equipment failure or human error, we not only lose the oil but also are required to pay a fine. This plan requires containment or diversionary structures around all the storage facilities. These structures can be dikes, retention pits, or drainage ditches. Periodic inspection of the facilities and records of these inspections are required. Also, periodic briefings are presented to our operating personnel on methods of spill prevention. Each SPCC Plan must contain a list of personnel, including their telephone numbers, available to clean up a spill. Materials available to clean up a spill also are listed. The plan must be inspected and signed by a registered professional engineer and posted at the facility. For additional information concerning the SPCC Plan, the API (American Petroleum Institute) Bulletin D16 can be obtained. The bulletin, which was published in March, 1974, includes suggested procedures for development of SPCC Plans.

Gas is sometimes produced with the oil and must be compressed to a higher pressure to enter various pipelines. Entry depends on the pressure of the pipeline. Some compressor stations are large in size--300 H.P. or greater. These stations use a cooling tower to reduce the temperature of the gas before it enters a pipeline. The cooling medium is sometimes water which is discharged into streams. A permit is required by the state and the EPA for this discharge. Chemical analyses are required at regular intervals. Temperature and pH have maximum and minimum requirements. Oil and grease must be 10 ppm or less. If it is greater, separator or skimmer equipment must be installed. No discharge of floating solids or visible foam in other than trace amounts can be discharged. Drip pans are provided under equipment subject to minor oil leaks. The waste oil is disposed by burning in an approved boiler.

Oil wells must have adequate cement plugs between producing and saltwater zones and above and below freshwater horizons. During the first two decades of this century, the technology did not exist adequately to protect freshwater reservoirs from saltwater intrusion. Surface pollution was also visibly evident. With the development of oil-field cement and cementing techniques, improved tubular goods and valves, and various types of electric logs, appropriate agencies in the various oil-producing states began requiring the oil industry to protect fresh surface and subsurface waters from pollution during drilling, producing, and plugging operations. As the technology for performing these tasks advanced, state regulations became more and more stringent. Most states now completely prohibit the storage of salt water in unlined pits; fresh water reservoirs are separated from injection or disposal wells by a solid cement sheath and two or more pressure-tested casings. In "sensitive" areas, even injection pressures are regulated to preclude the possibility of salt water channeling to freshwater horizons. These state agencies are staffed with trained engineers, geologists, and other professionals who are experienced in supervising the development of oil and gas resources and dedicated to the exacting task of enforcing the regulations. The state agencies have very effective enforcement authorization including "pipeline severance," which prohibits the sale of oil or gas from a non-complying operator's lease.

For additional information on the extent of how existing policies take into consideration the impact on ground-water quality, one can obtain the API Bulletin D18, Environmental Protection Laws and Regulations Related to Exploration Drilling, Production and Gas Processing Plant Operations. This bulletin, published in March, 1975, contains laws and regulations from 30 states and two federal agencies. It is a reference guide only; it does not tell all one needs to know on existing laws, but it does tell where one can secure the regulations. Also available are two API Division of Production publications: API Recommended Onshore Production Practices for Protection of the Environment (RP51) and API Recommended Land Drilling Operating Practices For Protection of the Environment (RP52). These bulletins contain more detailed discussions of recommended practices, while the D18 bulletin is a supplement and a companion piece to the other two.

To develop a national policy for ground-water quality protection will court disaster if it is uniform, rigid, and inflexible. A comprehensive review of the current state and federal laws needs to be made. What might be appropriate for one state could be inappropriate for another. To apply West Virginia, Florida, or Michigan requirements to California simply would not make sense. First, one needs to establish the amount of contamination of present or potential underground sources of drinking water, determine what precautions the state has taken, and then establish minimum requirements only where needed.

State and federal regulations pertaining to the ground-water protection need to be coordinated. If a state has been carefully protecting the drinking water of its citizens, those wells and operations should not be made to comply with generalized and unworkable nationwide standards. This will result only in additional reporting requirements and will contribute to inflation without any significant improvement in the quality of drinking water. One needs to lessen the impact on oil production and eliminate the administrative shortcomings.

Additional regulations could substantially decrease ultimate recovery of hydrocarbons. If more regulations are needed to insure that underground sources of drinking water will not be endangered, then only well-documented evidence from major oil and gas producing states must be obtained to show that, in fact, additional requirements are essential.

In summary, we can admit that the industry appreciates fair and necessary regulations which protect the environment from possibly harmful actions of over-competitive, careless, or non-prudent operations. The industry appreciates equal treatment among all operators in the enforcement of these laws and regulations. We can safely say that we know of no currently occurring examples of ground-water pollution from our operations, and we see no need for further regulations. Protection costs money, and the cost of regulatory actions are passed on to the consumer.

DISCUSSION

A participant from the audience emphasized that protection of ground water for uses other than drinking water is important. For example, mineralization of ground water that is suitable for irrigation might render it unfit.

Another participant commented that in looking at all potential sources of contamination, activities associated with oil and gas drilling and development pose a minor problem. A much greater problem exists from the transport of hydrocarbons and their storage.

IMPOUNDMENTS FOR LIQUID WASTES:

POLICY IMPLICATIONS

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INTRODUCTION

A public policy for impoundments (pits, ponds, and lagoons) is self-evident--impoundments should work for intended purposes without damaging the environment. The "environment" of interest here is ground water; however, ground and surface waters are inseparable, especially where impoundments are concerned.

An impoundment whose function is to store or contain a substance (usually liquid) must be designed not to break, overflow, or leak. An impoundment whose function is to recharge water to an aquifer should leak water effectively.

Obviously, the stringency of the design requirements must reflect the potential for contaminating ground (and surface) waters. In almost all cases, this comes down to two questions: What substances go into the impoundment? Where is the impoundment located?

For ground water, these issues are being addressed in two recently enacted federal laws: the Safe Drinking Water Act (P.L. 93-523), which deals with the protection of underground sources of drinking water; and the Resource Conservation and Recovery Act (P.L. 94-580), which deals with hazardous wastes.

Under P.L. 93-523, regulations have been proposed to inventory ponds, pits, and lagoons. One purpose of this inventory is to decide whether or not to regulate these impoundments by considering them as "well injection practices." Although implementation of P.L. 94-580 is just getting underway, it contains two interesting definitions. "Disposal" is defined to mean ". . . the leaking or placing of any solid waste or hazardous waste into or on any land or water so that such discharged into . . . ground waters." "Solid waste" is defined to include ". . . other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities. . . ." There is no question that these definitions apply to waste impoundments.

As compared to surface water pollution, control of ground-water pollution may be taking a strange turn. Regulation of surface water pollution has always focused on controlling pollutants which may enter the nation's streams. Control of ground-water pollution is focusing on certain physical structures or mechanisms.

The application of regulations to protect ground water from pollution by impoundments seems to hinge on abstruse debates over whether or not a pit is an injection well or a lagoon is an open dump or sanitary landfill. Admittedly, this is a result of "tacking on" ground water to federal laws dealing essentially with other subjects. Some authority to deal with a problem is perhaps better than none. However, things are beginning to sound a bit peculiar.

> (Editor's Note: Mr. Schiffman's excellent presentation included a series of 32 slides. These slides depicted specific examples as a "case history" of impoundments in Maryland. Although the slides are not presented as part of this paper, the commentary, when otherwise meaningful, is.)

POISON PITS

Waste lagoons often receive hazardous wastes in unknown quantities as the end product of resource recovery operations. "There will always be a residual" and, more often than not, it will end up on the land.

The organic solvent wastes (N, N-dimethylformamide, ethyl alcohol, acetone, dichloromethane, 2-ethoxyethanol, diacetone alcohol, 4-methyl, 1-2-pentanone, and 2-ethoxyethyl acetate) are considered hazardous. One company was recently required to remove and treat the wastes and properly reclaim the disposal area in order to prevent further contamination of waters of the state.

There are over 100,000 tons per year of Hexavalent chrome waste generated in Maryland. Liquid waste impoundments are often secondary features of these larger waste disposal problems.

Ponds are often used for disposal of septic tank clean-out wastes. The fate of many waste residuals is not well known. Septic tank clean-out wastes are often disposed of in sewers or at sewage treatment plants. Sometimes there is a charge for this service. There are little, if any, costs associated with dumping in an unregulated pond.

Waste lagoons for disposal of highly dissolved solids and metals are typical of many small industries in Maryland.

Plating wastes are often disposed of into waste holding ponds. These wastes contain metals such as chromium, lead, cadmium, nickel, cyanides, and arsenic. In one investigation in 1975, 15,000 gallons of wastewater were discharged into a pond each day. The pond was unlined, had a capacity of 2,400 cubic feet, and had been in operation since 1952.

Geophysical surveys were conducted, test wells drilled, and water and earth samples obtained for analyses. Although the geophysical data indicated a zone of contamination with a radius of about 1,000 feet and a depth of 50 feet, ground-water samples indicated that the quality of the underground waters was hardly affected by metals. In addition, the natural quality of the ground water was brackish. The earth samples were then analyzed and it was determined that sandy-silty clayey horizons between about 20 feet and 45 feet deep contained "coatings" on the grains high in chromium and metals.

The main problem here is that this lagoon occasionally overflows and contaminates surface waters. The combination of hazardous liquid wastes and a leaking lagoon does not necessarily equal a major ground-water pollution problem.

A company in Maryland has been treating wood by high pressure injection of creosote since 1965. Waste by-products of the treatment (phenolics, tannins, lignins) were disposed of in clay-lined lagoons. In early 1975, it was discovered that the waste from the lagoons was leaking into a freshwater holding pond downslope of the lagoons. The waste then flowed into a small stream.

A geophysical survey of the area was made and test wells drilled. It was determined that there is an extensive zone of contamination nine feet below ground surface moving in the direction of the freshwater pond and stream.

The contamination is largely phenolic wastes. Areally, the entire stream channel, from the plant to a marshy area two miles away, is contaminated. At various points along the stream, phenolic wastes are visibly moving into the stream channel along with ground-water flow. The concentration at which the phenolics occur is enough to have a deleterious effect on life in the stream (2.1 mg/l in the stream and 14.4 mg/l in the ground water).

In this case, the ground water became contaminated and, in turn, so did the nearby stream. Impoundments are surface features, and when they leak there will often be contamination of unconfined aquifers.

INDUSTRIAL WASTE-TREATMENT LAGOONS

Large settling lagoons (several acres) are used for wastewater containing silica gel. Lagoons which receive wastes often have a tendency to fill up, necessitating removal of the wastes.

Large lagoons for titanium dioxide plants contain basically a calcium sulfate sludge. The sludge is watery and difficult to handle.

Steel plants use lagoons to contain dredge spoil. The dredge spoil is contaminated by heavy metals and other substances. The act of dredging and placing the spoil in the lagoons will cause some substances to go back into solution. Some of the biggest waste impoundments are located in or next to streams and estuaries and have little, if any, impact on ground water.

AGRICULTURAL IMPOUNDMENTS

Farm ponds are used for irrigation and stock watering. There are large numbers of these ponds.

Waste lagoons are used on hog farms. Some areas have contamination of ground water by nitrates. However, in agricultural areas, there are often many sources of nitrates.

Disposal ponds serve tomato canning operations. Ponds contain waste lye-peeler solution (sodium hydroxide) used to strip the skins from tomatoes.

Waste ponds are used on dairy farms. In dealing with waste impoundments, agricultural interests will have to be reckoned with. Many agricultural waste lagoons were constructed to help avoid pollution of streams. Under close scrutiny, many will likely be shown to have an adverse impact on ground-water quality.

SEWAGE TREATMENT LAGOONS (OXIDATION PONDS)

In oxidation lagoons, domestic wastes are aerobically decomposed and then may be spray-irrigated on the surrounding woodlands. In addition to treating the sewage, the lagoons provide storage for times when spraying is not feasible (inclement weather). Virtually all spray irrigation projects require some kind of storage facility--usually a lagoon.

An example of a problem with a sewage-treatment lagoon involved a pair of lined (reinforced rubber) lagoons for a roadside rest stop. Originally the lagoons were lined with tar-impregnated fiber mats placed on top of rock. Although it was visibly obvious that the lagoons would not hold water, people involved were reluctant to believe that they did leak until dye tests were made. A liner was then installed and guaranteed not to leak by the manufacturer.

This was a million-dollar project and many people were upset at the delays caused by the leaking lagoons. To assure that everything was working, the lagoons were tested by installing a water level recorder in each lagoon. In the lagoon on the right, the water level declined at a much greater rate than its identical twin. People were reluctant to concede that the lagoon leaked and seriously proposed that there was differential evaporation. When the leaking lagoon was emptied, it was found that the liner had ripped at joints around the inlet pipe and its supports. It should be noted that the test did not prove that one lagoon leaked, only that one leaked more than the other. It seems that there is a need to inspect the construction of impoundments because of the difficulty of leak tests after construction.

An example of problems associated with sewage oxidation ponds occurred on the eastern shore of Maryland where ponds, purported to be the largest sewage ponds of this kind east of the Mississippi River, occupy an area of 180 acres. The ponds receive combined sanitary sewage and industrial waste from a small town with the industrial waste (largely sodium chloride pickling brines from a pickle company) making up most of the waste flow. Geophysical surveys were conducted, test holes drilled, and ground-water samples taken for analyses. It was determined that the lagoons leak. The zone of ground-water contamination around the ponds is of a complex configuration and extends out from the ponds to a maximum distance of approximately 1,000 feet with the general direction of ground-water flow towards a small stream. Chloride values in the ground water as high as 220 mg/l were measured.

Evaluation of ground-water quality in the vicinity of pickling and brine tanks at the pickle company revealed that the ground water in the area was grossly contaminated, from past and present leaking tanks and spillage, to a distance of about 400 feet in each compass direction and to a depth of at least 75 feet. The well-water supply of six nearby homes was polluted (chloride values up to 1690 mg/l were measured) and the water was unfit for human consumption. In addition, one of the company's wells had a chloride content of 6300 mg/l. The contrast in impact between the leaking lagoon (chlorides from pickle-brine wastes) and the leaking pickle barrels (chlorides from pickle brine) is obvious.

SEDIMENT CONTROL IMPOUNDMENTS

Sediment control ponds are used at large construction projects and gravel mining operations to trap sediment and to prevent sediment pollution of streams.

Sediment control ponds serve at landfills that receive industrial wastes. These industrial waste landfills often receive contaminated water. Thus, the name and function of an impoundment is not always a reliable indicator of the potential pollution risk to ground water.

MISCELLANEOUS IMPOUNDMENTS

Two covered lagoon facilities in Maryland are used for storage of liquid nitrogen fertilizer. These facilities are excavated ponds lined with a polyvinyl chloride membrane and covered with a roof. They have a total capacity of approximately 580,000 gallons.

In early 1975, an investigation was made of the potential of these facilities to cause ground-water pollution. This study was prompted by inquiries from local citizens concerned about the safety of their shallow-well water supplies. Primary Drinking Water Standards of the federal government set a maximum limit of 10 mg/l nitrate nitrogen for public water supplies.

Geophysical surveys were made in the area, monitoring wells constructed, core samples taken for geologic analyses, and water samples obtained for chemical analyses. The data showed that to a depth of at least 50 feet and for a distance of at least 50 feet around the edges of these liquid nitrogen storage facilities, the quality of the ground water is being degraded. In some cases, values of nitrate as much as 10 times greater than background values of 0.1-4 mg/l were measured. Test wells on the perimeter of these facilities produced ground water with values for nitrate nitrogen as high as 27 mg/l. It was not possible to determine whether or not the high nitrate values in the ground water are due to the ponds leaking or poor housekeeping (spills, leaking underground and surface pipelines, etc.), or both.

Waste storage tanks are used for pesticides which include kepone. Major pollution risks are involved with leaks from this kind of waste storage.

Oil storage tanks are constructed with a raised berm (lagoon) around the tanks. If these tanks leaked, we would then have a liquid waste impoundment.

Maryland plans to compost 400 to 600 million tons of sewage sludge per day generated from the Washington Metropolitan Area. Until suitable facilities can be built, the sludge is being placed in trenches two feet deep at the rate of about 1,000 wet tons per acre.

Labels such as "pits," "ponds," "lagoons," and "impoundments" may do more harm than good. We are, after all, interested in protecting ground-water quality. We should not base regulatory decisions on the label we chose to affix to a containment structure. The following is an example of a problem where a liquid waste impoundment is an insignificant part of a bigger issue. A chemical company applied for a state and federal discharge permit to discharge wastes from a truck washing facility. It was initially proposed that wastes be disposed of in a lagoon to avoid a direct discharge to a stream. The main facility was to have been a storage depot for solvents and other chemicals and would have included underground storage tanks. A check on the location of the proposed facility showed that it is in the middle of a 2.5 mgd well field. Sufficient geologic data are available to show that there is a series of lenticular sands, silts, and clays about 140 feet thick above bedrock. The wells would have pumped from both shallow and deep sands. A thorough evaluation of construction specifications is essential for the proposed impermeable liners beneath the underground storage tanks, lagoons around the surface storage tanks, and ground-water monitoring facilities. Leakage of chemicals into ground water could conceivably destroy the well field.

CONCLUSION

National efforts which have concentrated on eliminating pollutants from the air and streams have caused people to forget that everything is entitled to be someplace--even wastes. It is only natural that these pollutants have tended to move towards areas of least regulation such as ponds, pits, and lagoons.

Impoundments are used for many different purposes and come in a wide variety of sizes and shapes. There is little question that most leak to one degree or another and that many could experience structural failure or overtopping. It is also obvious that not all liquid waste impoundments are located where ground water can become contaminated and not all cases of ground-water contamination from leaking impoundments involve wastes.

Impoundments are not radically new structures. Construction standards for dams and reservoirs developed by different groups such as the Soil Conservation Service are readily applicable to waste impoundments. Data are available for different liner materials and there are straightforward techniques for calculating leakage.

The national policy for waste impoundments should be that they work for intended purposes without adversely impacting ground water. The national dilemma is that many state regulatory agencies will be overwhelmed trying to find and control all impoundments which could contaminate ground water.

Clearly, we must set priorities by delineating those aquifers most susceptible to contamination by impoundments and the substances and circumstances most likely to cause serious damage. We can probably protect some aquifers from serious pollution all of the time, and possibly protect all aquifers from pollution some of the time, but we can never protect all aquifers from pollution all of the time.

DISCUSSION

During the discussion, considerable interest was expressed in the pros and cons of monitoring. The Maryland approach is to do some monitoring for impoundments; however, the key to avoiding ground-water pollution from impoundments is in facility design. Monitoring should not be a means of determining that pollution is occurring, but rather as insurance that the impoundments perform as designed. The key point is that the ground-water system monitored must be the system that could be affected by a leaking impoundment.

The question was raised concerning ground-water standards and whether they would help relieve the problem. Mr. Schiffman replied that impoundment construction standards and construction requirements would do more to prevent ground-water pollution than setting standards on quality degradation, although limited degradation is a realistic approach to ground-water quality protection.

AGRICULTURAL PRACTICES:

POLICY IMPLICATIONS

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Agricultural practices can seriously affect the quality of ground water. Intensive units used for animal production, such as beef feed lots, produce large volumes of concentrated wastes which may, if unmanaged, contaminate ground water. These wastes, however, are generally capable of treatment and disposal as point sources, and technology ensuring sound wastewater management has been fully developed. Problems of ground-water pollution due to agricultural point sources are then more likely to be economic rather than technical.

This paper discusses the more subtle and controversial problem of agricultural non-point sources of ground-water contamination. The controversy concerning the significance of non-point agricultural sources is due in part to their relative novelty.

Historically, a major impetus to the development of adequate wastewater management originated with the need to protect ground-water aquifers serving as water supplies to large cities. Thus, the primary concern was to eliminate pathogens. By mid-20th century, the emphasis was directed towards the elimination of organic pollution in wastes from point sources by primary and secondary effluent treatment. The widespread adoption of such treatment, and the consequent reduction in organic pollution in the nation's waters, has revealed background levels of inorganic substances and residual materials which are ubiquitous in both surface and ground waters. In this sense therefore, there has been an unveiling of types of pollution and we are again concerned about the quality of our ground water as it affects public health.

As greater attention has been given to non-point sources, so agriculture has come to be regarded as a primary factor, especially with respect to the enrichment of water by nitrogen. Two simple arguments buttress this supposition: first, there have been spectacular increases in the use of chemicals by the agricultural industry in the last twenty years; second, agricultural areas constitute about 50 percent of the 48 contiguous states, and hence the cumulative impact of so extensive a land use must be commensurately significant.

On the other hand, non-point sources are not amenable to direct measurement, by definition, especially when considering large areas. Also, knowledge about the use of agricultural chemicals, and their subsequent fate is incomplete. It may be counterargued therefore, that the evidence regarding the significance of agricultural sources relative to others is inconclusive. A considerable effort is now being made nationwide to determine the relative importance of agricultural and other non-point sources of contaminants. Under Section 208 of the Federal Water Pollution Control Act Amendments of 1972, management programs must be developed which specifically include agriculture.

One of the largest such programs in the nation is currently being developed for the Nassau-Suffolk region of Long Island. This paper will briefly outline part of that program which is attempting to assess the impact of agricultural chemicals on ground water. The study is being undertaken through Cooperative Extension of Suffolk County - Cornell University. The specific objectives of the study are: (a) estimate the use of agricultural chemicals in Nassau and Suffolk Counties, (b) assess the impact of such use on ground water, and (c) to develop appropriate management and public policies.

The actual and potential contamination of the ground-water resources is a critical matter for the bi-county region, which depends wholly for its water supplies on the aquifers. The gravity of the region's position is indicated in Table 1. Note that, according to the projections, there will be sustained increases in population, especially in Suffolk County. Correspondingly, the demand for water is expected to increase, both in total volume and per capita. It should be noted especially that demand is expected to exceed the supply in the early 21st century although there is considerable debate about the potential available water supply from the aquifers.

The current pattern of land use is shown in Table 2. As can be seen from the table, the largest single land use is residential which accounts for nearly half of the total land area, when surface water is omitted. In the next decades, areas used for housing will increase as the population increases. It would follow, therefore, that residential areas are and will continue to be the primary source of wastes in Nassau and Suffolk Counties. This is particularly the case for nitrogenous substances, especially considering nitrogen applied to garden lawns and nitrogen leaching from the large number of septic tanks used in the bi-county region.

Hypothetical waste loadings of nitrogen which would leach to ground water under different conditions are shown in Table 3. The different conditions would apply according to the degreee to which sewerage was provided in the bi-county region, the amount of ammonia volatilization and denitrification which occurred during or before treatment, and the fraction of wastewater which was discharged to the marine environs. All such possibilities would represent a new loss of nitrogen to the Nassau-Suffolk area. Thus, the actual population equivalent of the wastewater discharged on the Island would be less than the potential nitrogen load in the original waste, as indicated in the table.

Correspondingly, the actual loads of nitrogen originating from fertilizers may be similarly computed for comparison. Table 4 shows hypothetical losses of nitrogen to ground water in terms of loads, concentrations, and population

TABLE 1

Estimates of Population and Associated Water Demands in Nassau and Suffolk Counties

Regional Entity	Estimates and Projections				Permissive Yield (MGD)
	1971	1980	2000	2020	
Nassau County					
Population (thousands)	1434	1610	1940	2250	
Public Water Demand					
(MGD)	184	199	252	304	151
(GPCD)	128	124	130	135	
Suffolk County					
Population (thousands)	1148	1601	2518	3060	
Public Water Demand					
(MGD)	161	231	366	474	466
(GPCD)	140	141	143	154	
Bi-County Totals					
Population	2582	3380	4458	5310	
Water Demand	245	430	618	778	617

equivalents under various assumptions. Rates of application of nitrogen on agricultural land on Long Island commonly fall between 100 pounds to 300 pounds per acre, with an average rate of about 200 pounds. Assuming that each rate is applied uniformly, it is possible to compute the amount lost according to the percentage of nitrogen not removed in the crop.

If the highest rates of loss at the highest rate of fertilizer application are assumed, then the population equivalent would be about 0.5 million. It should be recognized that such losses would occur on less than 50,000 acres (Table 2). Therefore, the population equivalent at the highest rate of loss would be approximately 10 persons per acre. It may be shown assuming a recharge rate of 22 inches per year, that a nitrate-nitrogen load in the percolating water equivalent to four or more persons per acre, will result in a concentration greater than the Public Health Standard of 10 ppm.

As already suggested, however, in terms of area the major crop grown in Nassau and Suffolk Counties is ornamental grass. Estimates of nitrogen losses from fertilized turf in the two counties are shown in Table 5, and assume a total acreage of turf of 150,000 in the two counties.

TABLE 2

Land Use Data for Nassau and Suffolk Counties

Land Use	Area (Acres)	% of Total
Residential		
1. Very low density	13,255	1.2
2. 0-1 dwelling units/acre	86,061	7.9
3. 2-4 dwelling units/acre	124,412	11.4
4. 5-10 dwelling units/acre	99,172	9.1
5. Over 10 dwelling units/acre	9,743	.9
Total	332,643	30.5
Economic		
6. Commercial	20,183	1.9
7. Industrial	10,602	1.0
8. Institutional	30,128	2.8
9. Utilities	14,038	1.3
10. Agriculture	42,399	3.9
11. Duck farm	1,027	0.1
12. Landfill	945	0.1
Total	119,322	11.0
Open		
13. Open space	117,045	10.8
14. Vacant	177,078	16.3
15. Water	342,621	31.5
Total	636,744	58.5
Grand Total	1,088,709	100.0

The rates of application assumed in the table include rates commonly recommended for turf culture. Concerning rates of loss of nitrate-nitrogen from turf, very few relevant studies appear to have been undertaken. Investigations of the efficiency of the use of fertilizers on grassland are not directly applicable because such grass is usually cropped in an animal production system. Studies of ornamental grasses have traditionally been more concerned with the quality of the sward rather than with losses of nitrogen due to leaching. A recent exception is the study by Rieke and Ellis (1974), who found that significant leaching of nitrate-nitrogen occurred following heavy applications of either fertilizer or irrigation.

Bouldin (1977) makes the argument that all inputs of nitrogen to mature turf must be lost to the environment by one or more possible routes. The argument

TABLE 3

Hypothetical Waste Loading from Assumed Populations

% N Lost Other Than to Ground Water[1]	Parameter	Population (millions) 3	5	7
	Total load[2]			
10	kg (millions)	16.2	27.0	37.8
	Conc. (ppm)[3]	10.0	16.6	23.4
	P.E. (millions)[4]	2.7	4.5	6.3
30	kg (millions)	12.6	21.0	29.4
	Conc. (ppm)	7.8	13.0	18.2
	P.E. (millions)	2.1	3.5	4.9
50	kg (millions)	9.0	15.0	21.0
	Conc. (ppm)	5.5	9.2	12.9
	P.E. (millions)	1.5	2.5	3.5

[1] Assumed rates of loss to atmosphere or oceans as opposed to ground water.

[2] Assumes 6 kg N/person/year.

[3] Non-wasted nitrogen is leached and is diluted by 746,088 x 1.76 acre-ft. of recharge water.

[4] One P.E. (population equivalent) is the average amount of nitrogen in the waste of one person per year (6 kg N/person/yr).

is depicted simply in Figure 1. Sources of nitrogen and possible transformations and transport are shown in Figure 1A. If there is a net accumulation of organic nitrogen in the turf, then the losses of nitrogen (E) will be less than the gains (A). Through time, however, the turf may enter a period of equilibrium during which there is no change in the amount of nitrogen stored in the soil. In which case, A = E in Figure 1. Further, due to conditions on Long Island, the process of ammonia volatilization and dentrification are probably insignificant. Soils on the island generally have a very low pH and are well aerated. Therefore, any addition of nitrogen to the turf will eventually be lost by leaching from it.

In terms of the estimates shown in Table 5, the higher hypothetical losses would therefore appear to be most probable. However, at the outset of the study, there was a lack of data regarding the use of fertilizers, both by householders and all other users. Thus, a primary objective in this study was to estimate the total quantities of fertilizers used in Nassau and Suffolk

TABLE 4

Estimated Losses of Nitrogen from Cropland to Ground Water,
Assuming Three Rates of Annual Application
and Percentages of Hypothetical Loss

% Loss to Ground Water	Parameter	Application to Cropland (lbs/ac)[3] 100	200	300
	Total load			
	kg (millions)	0.6	1.1	1.7
25	Conc. (ppm)[1]	5.1	10.2	15.3
	P.E. (millions)[2]	0.1	0.2	0.3
	kg (millions)	1.1	2.3	3.4
50	Conc. (ppm)	10.2	20.4	30.6
	P.E. (millions)	0.2	0.4	0.6

[1] The leached nitrogen is diluted by 746,088 x 1.76 acre-ft. of recharge water.

[2] One P.E. (population equivalent) is the average amount of nitrogen in the waste of one person per year (13.2 N/person/yr).

[3] Rates are commonly expressed in lbs/acre.

Counties, and to determine the subsequent fate of the nitrogen so applied.

Parallel to the situation with respect to fertilizers, there exists very little detailed information which describes the total use of pesticides within specific regions, as opposed to purely agricultural use. The only previous extensive study of the use of pesticides by householders was undertaken in 1971 (EPA, 1972). It was therefore a further objective of this investigation to estimate which pesticides are being applied on Long Island and in what quantities.

FIELD SURVEY TO DETERMINE USE OF FERTILIZERS AND PESTICIDES

Early in 1976, a questionnaire was developed to be used in a field survey to evaluate fertilizers and pesticide practices on Long Island. A pilot survey was made in June in Riverhead, Suffolk County, to test the questionnaire and interview procedures. Subsequently, seven areas were chosen in Nassau and Suffolk as shown in Figure 2. Selection was based on the average income level and population density within each area. It was determined by statistical analysis that a sample of 60 houses in each area would provide a sufficient

TABLE 5

Estimated Losses of Nitrogen from Fertilized Turf, Assuming Three Rates of Annual Application and Percentages of Hypothetical Loss

% Loss to Ground Water	Parameter	Application to Grass (lbs/1000 ft^2)[3] 1	3	6
	Total load			
	kg (millions)	1.5	4.4	8.9
25	Conc. (ppm)[1]	4.6	13.8	27.6
	P.E. (millions)[2]	0.3	0.7	1.5
	kg (millions)	2.2	6.7	13.3
50	Conc. (ppm)	6.9	20.7	41.4
	P.E. (millions)	0.4	1.1	2.2

[1] The leached nitrogen is diluted by 746,088 x 1.76 acre-ft. of recharge water.

[2] One P.E. (population equivalent) is the average amount of nitrogen in the waste of one person per year (13.2 N/person/yr).

[3] Rates are commonly expressed in lbs/1000 ft sq.

reliability of estimation. The houses themselves within the area were selected according to a simple random selection procedure.

Preliminary results of the survey with respect to nigrogenous fertilizers applied to lawns are shown in Table 6. As expected, rates of application tended to increase as incomes were greater. It should be noted that the rates given apply to the period up to the end of the field survey. A subsequent survey conducted by mail indicated that average rates of application should be increased by 50 percent to give annual rates.

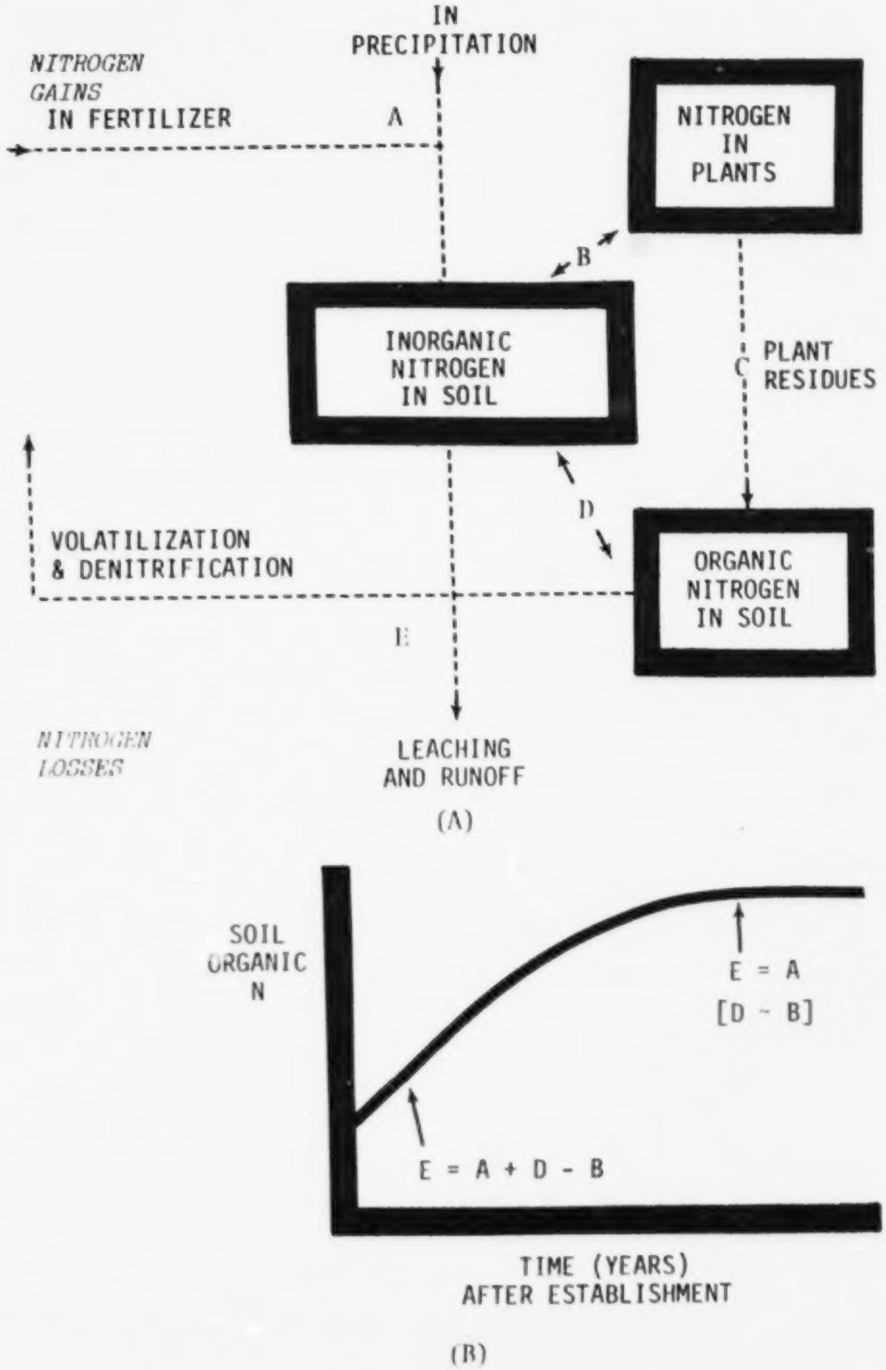
Preliminary estimates from the survey indicate that over 7,000 tons of nitrogen were applied to lawns in 1976 throughout Nassau and Suffolk. This compares with approximately 5,000 tons used in agricultural production in Suffolk County. Thus, the total use of nitrogenous fertilizers in the bi-county region is estimated to be in excess of 12,000 tons as nitrogen.

A summary of the use of pesticides by householders and other major users, as estimated by the field surveys, is given in Table 6.

Agricultural and household uses are clearly the major uses of pesticides in the region. As with fertilizers, both uses are of comparable magnitude. The

FIGURE 1

Soil Nitrogen Balance Under Turf
and its Expected Disposition Towards Equilibrium
[after D.R. Bouldin]


IN
PRECIPITATION
NITROGEN
GAINS
IN FERTILIZER
A
NITROGEN
IN
PLANTS
B
INORGANIC
NITROGEN
IN SOIL
C
PLANT
RESIDUES
D
VOLATILIZATION
& DENITRIFICATION
ORGANIC
NITROGEN
IN SOIL
E
NITROGEN
LOSSES
LEACHING
AND RUNOFF
(A)
SOIL
ORGANIC
N
E = A
[D - B]
E = A + D - B
TIME (YEARS)
AFTER ESTABLISHMENT
(B)

large quantities of herbicide used reflect the increasing tendency to use chemical means of weed control, a trend that is nationwide.

The assessment of the potential and actual impact of this pesticide use on ground-water quality is being based primarily on already existing data and information and is to be reported elsewhere (Porter and Beyer, 1977).

A similar assessment of the impact of nitrogen, originating from the use of fertilizers, on ground water was not found to be possible due to the paucity of data. Hence, a program of field monitoring was undertaken throughout most of 1976.

FIELD WORK TO MONITOR FATE OF NITROGEN FOLLOWING FERTILIZATION

Twenty representative sites were selected in Nassau and Suffolk for the monitoring of nitrogen. The sites represented a variety of types of crops to which fertilizers were regularly applied. Where possible sites were chosen for which either meteorological or ground-water data were already being collected. The location of the most important sites is indicated in Figure 3. Measurements for inorganic nitrogen were made at several layers in the soil at each site every two to three weeks in 1976. Levels of nitrogen were determined both in and below the root zone at each site. It was assumed that any inorganic nitrogen detected below the root zone would eventually be lost to ground water. Little or no denitrification was expected given the light sandy soils which are general on Long Island.

Typical results obtained from the potato farms are shown in Figure 4. The levels of nitrogen shown were measured in a part of a two-acre field which was being managed according to the farmer's normal practice; about 190 pounds of nitrogen per acre being applied in a band early in April, followed by a further 100 pounds a month later.It may be noted that levels of inorganic nitrogen below the root zone, following fertilization, were found to be significantly above the background levels observed in March.

The other half of the field was managed in accordance with new recommendations developed by the Long Island Vegetable Research Farm (Meisinger, et al., 1977). This new recommendation, which is now under testing, requires less nitrogen to be applied in total by ensuring that the applications are made to coincide with crop requirements as closely as possible.

The levels of inorganic nitrogen measured in soil managed according to this strategy are depicted in Figure 5. In this case, about 50 pounds of nitrogen per acre were applied in late March, followed by another 100 pounds two months later. It may be observed that the levels are much lower then in soil given the normal amount of fertilizer. The difference is particularly marked when the two 12-20" layers are compared.

Measurements were also made of the concentrations of inorganic nitrogen in

FIGURE 2

Field Survey Areas to Estimate Household Use of Pesticides and Fertilizers

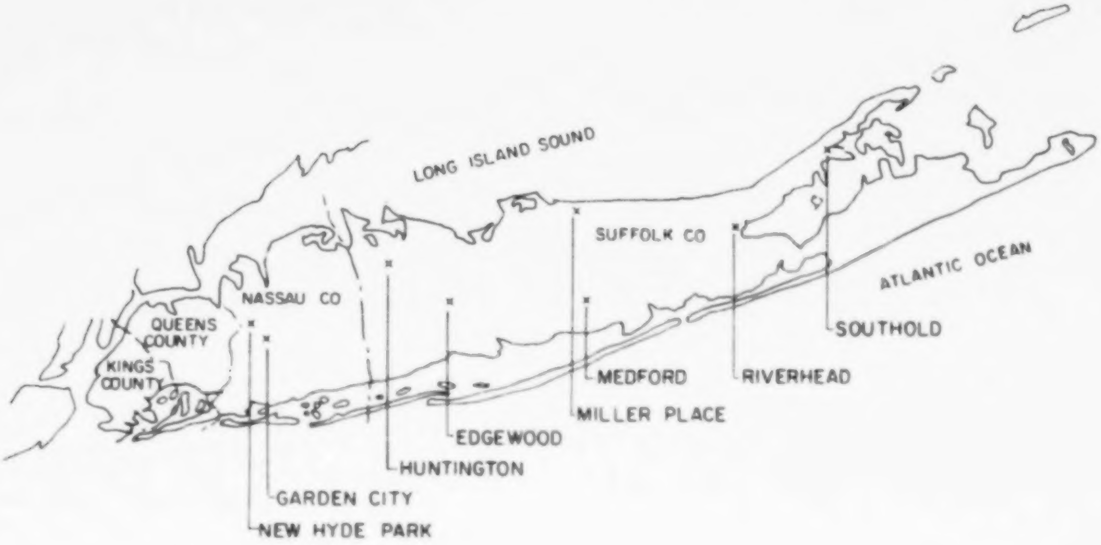

LONG ISLAND SOUND
SUFFOLK CO
ATLANTIC OCEAN
NASSAU CO
QUEENS COUNTY
KINGS COUNTY
SOUTHOLD
MEDFORD
RIVERHEAD
MILLER PLACE
EDGEWOOD
HUNTINGTON
GARDEN CITY
NEW HYDE PARK

FIGURE 3

Sites of Soil Nitrogen Field Survey on Long Island

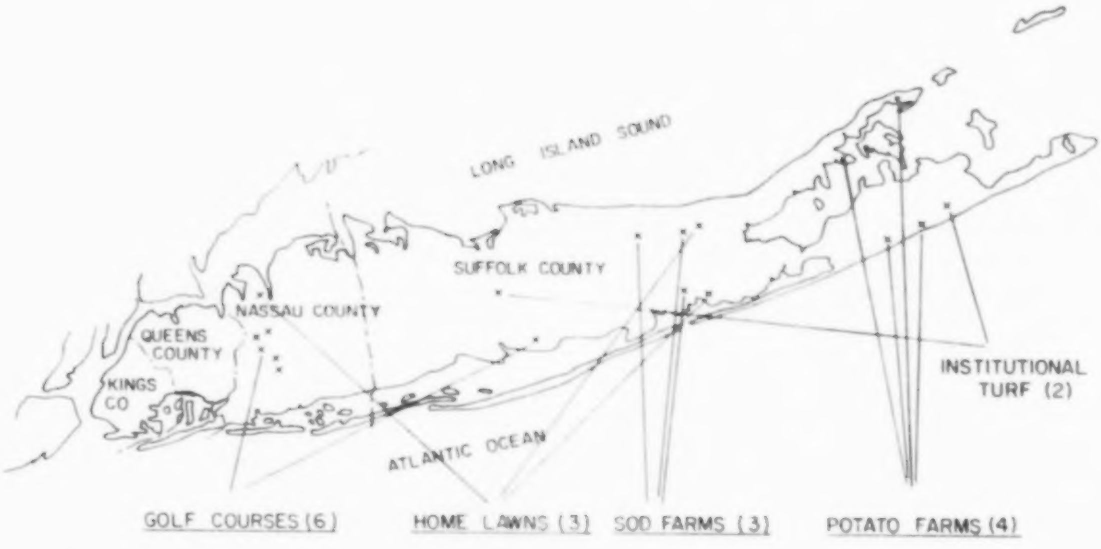

LONG ISLAND SOUND
SUFFOLK COUNTY
NASSAU COUNTY
QUEENS COUNTY
KINGS CO
ATLANTIC OCEAN
INSTITUTIONAL TURF (2)
GOLF COURSES (6)
HOME LAWNS (3)
SOD FARMS (3)
POTATO FARMS (4)

TABLE 6

Total Estimated Use of Pesticides in Nassau and Suffolk in 1976 (lbs of active ingredient)

Use	Insecticide	Herbicide	Fungicide
Transport and Utilities	1,077	14,110	10
Recreation	7,766	8,175	33,698
Agriculture	331,540	222,640	372,075
Household	230,031	155,602	442,821
Other	9,055	44	0
Grand Totals	579,469	400,571	848,604

ground water below both parts of the field, and upstream of the farms. In Figure 6, it may be seen that the observed concentrations were substantially higher in the ground water beneath the soil to which higher applications had been made. For further details regarding this and other farms the reader is referred to the paper by Meisinger, et al. (1977).

The major part of the soil monitoring survey was devoted to ornamental turfgrass. In particular, several series of measurements were made on mature turf at the Long Island Vegetable Research Farm. Various rates of nitrogen were applied to plots measuring approximately 100 sq. ft. in area. Results from two plots are shown in Figures 7 and 8. On the plot depicted in Figure 7, one inch of water was applied twice daily, and one inch applied once daily to that shown in Figure 8. In both experiments, the nitrate-nitrogen recovered in the measurements corresponded typically to the amount applied. In all cases, leaching was fairly rapid. Measurements made over a longer period of time, on various turfgrasses subjected to normal levels of precipitation and fertilizer applications also indicated commensurate losses of inorganic nitrogen in percolating water.

CURRENT ANALYSIS OF FIELD DATA

Using the hydrological and nitrogen data collected in 1976, attempts are currently being made to estimate the quantities of recharge over the Nassau and Suffolk region, and the consequent transport of nitrogen loads from major sources of nitrogen including fertilizers. Estimation of the mass flows involved is being based on detailed recharge and nitrogen models for the region. The basic spatial unit used in the models is defined by a grid cell system specified by the Nassau-Suffolk Regional Planning Board for land-use planning purposes. Each cell is 2.25 square miles in area, and the Board has developed land-use data for each cell in terms of the categories of land use given in Table 2.

FIGURE 4

Inorganic Soil N in Potato Field-Farmer's Current Management - 1976

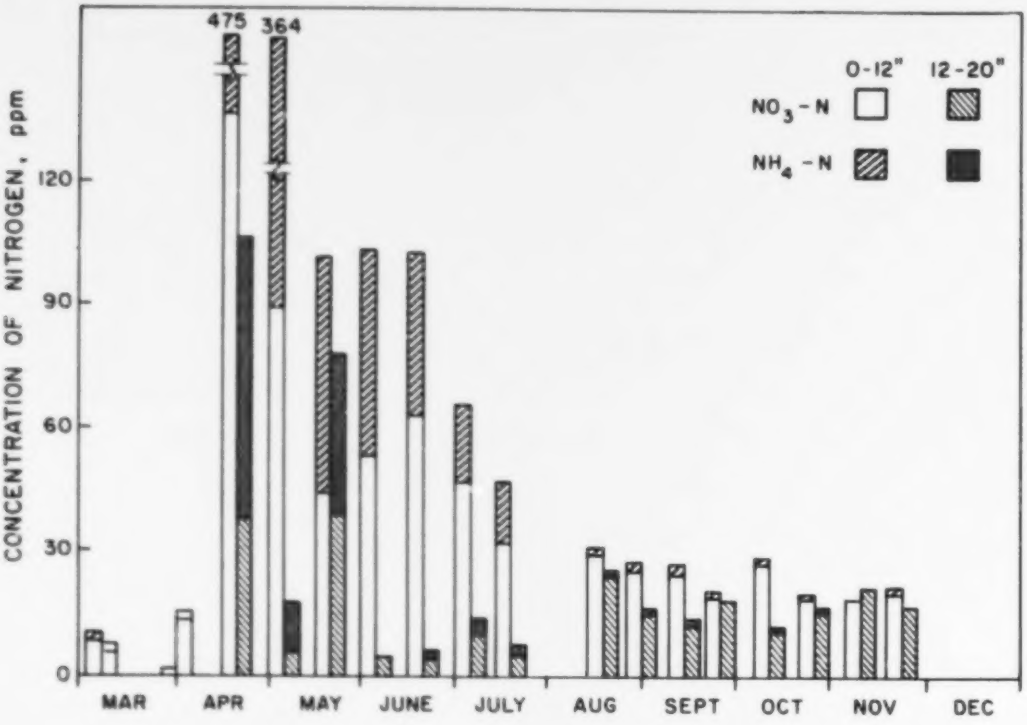


FIGURE 5

Inorganic Soil N in Potato Field-Cornell's Experimental Management - 1976

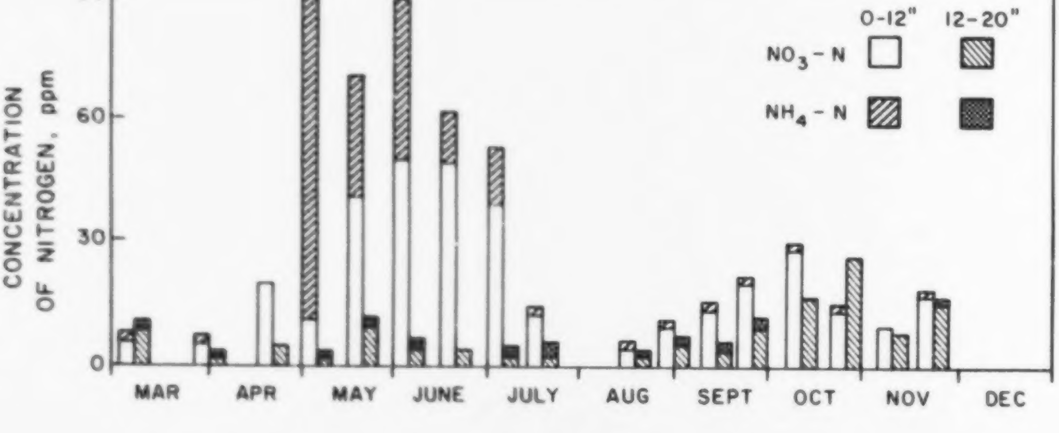
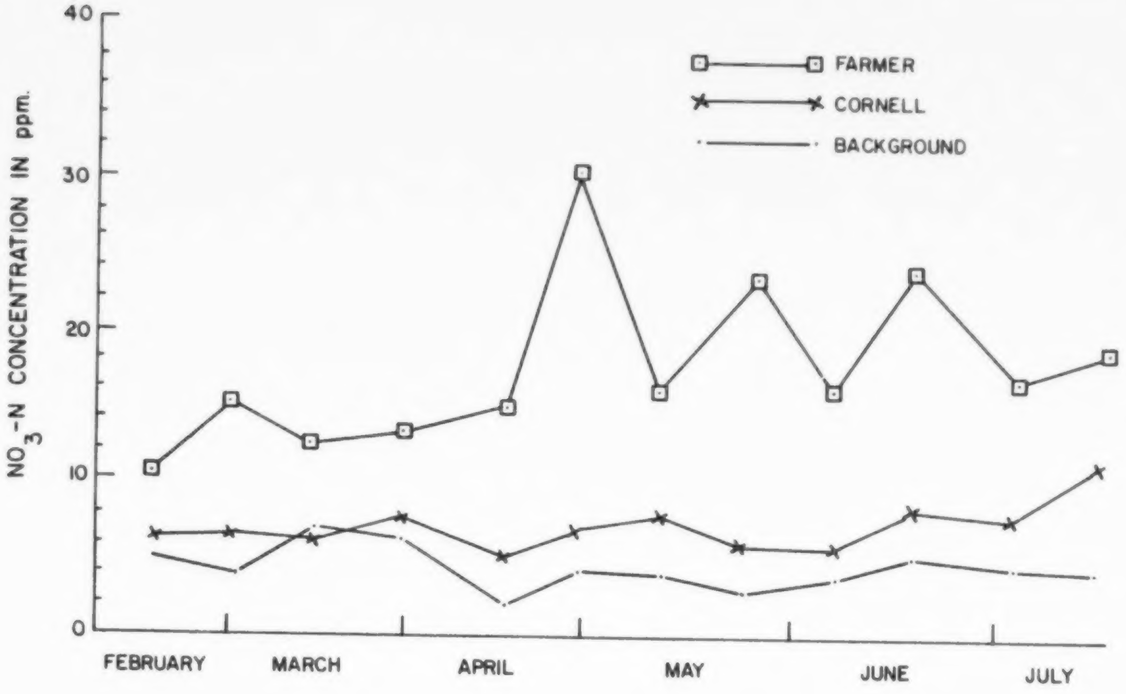


FIGURE 6

NO_3-N Concentration in Ground-Water Beneath Potato Farm



Both components of the hydrological cycle and major sources of nitrogen are in part functions of land use variables. The models make it possible, therefore, to assess the impact of the various land uses on recharge and inorganic nitrogen transported by the recharge water to ground water. For example, the amount of natural runoff on Long Island is relatively small compared to the amount of precipitation. The runoff which now occurs is primarily a function of impervious areas, which in turn are a function of land use.

A summary of some results obtained by the hydrological model is given in Table 7. The maximum and minimum values indicated for each of the components of hydrological cycle are those estimated for the individual cells and not the whole region. As shown in the table, the mean runoff and recharge are approximately 10 and 50 percent of the mean precipitation respectively.

No equivalent estimates for the whole of Nassau and Suffolk have previously been published. However, estimates of recharge and runoff have been made for several areas within the two counties. The result from these studies and those obtained by the hydrological model are shown in Table 8. There is good agreement between the two sets of results for recharge. In the case of the

FIGURE 7

Total Inorganic Nitrogen in Each Depth Layer
V. Amount of Water Applied

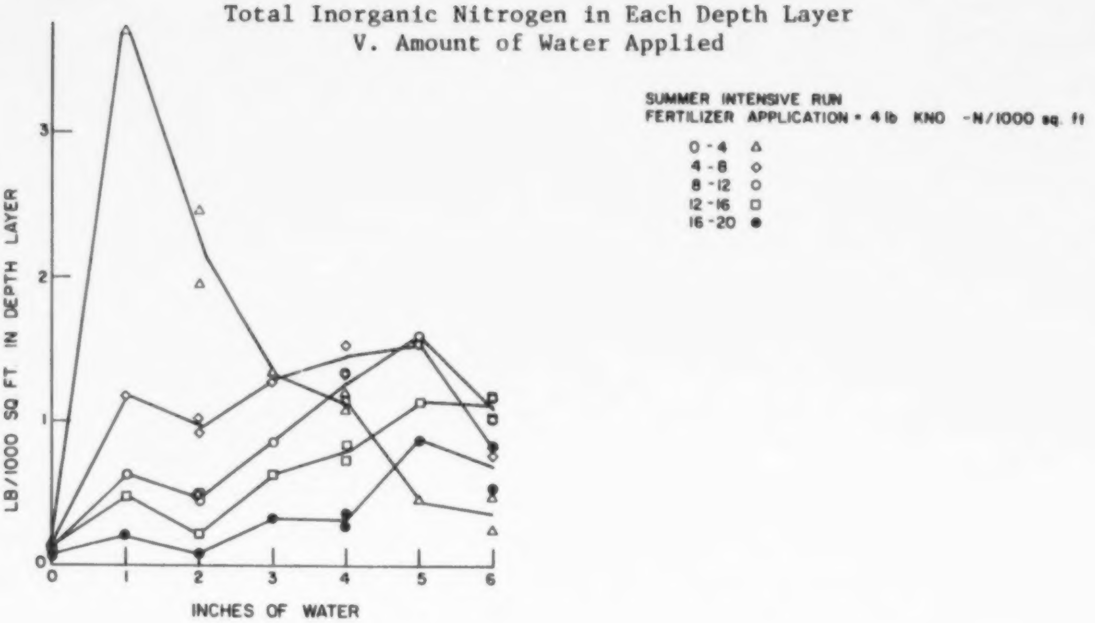


FIGURE 8

Total Inorganic Nitrogen in Each Depth Layer
V. Amount of Water Applied

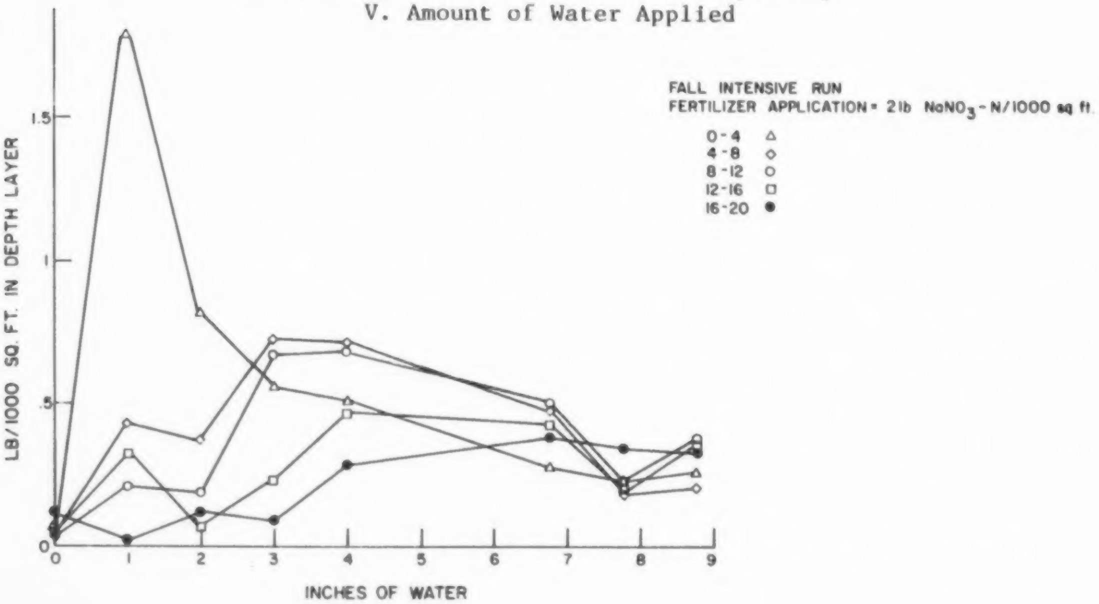


TABLE 7

Summary of Results from Hydrological Model Representing an Average Year

Month	Precipitation			Runoff		
	Max	Mean	Min	Max	Mean	Min
Jan	4.4	3.3	2.4	1.8	.33	0
Feb	4.4	3.5	2.8	1.9	.36	0
Mar	5.0	4.0	3.0	2.2	.42	0
Apr	4.3	3.6	2.8	2.1	.38	0
May	4.4	3.5	3.1	2.2	.38	0
Jun	3.7	3.0	2.5	2.1	.33	0
Jul	4.0	3.5	3.0	2.2	.38	0
Aug	4.6	3.8	2.4	2.3	.41	0
Sep	4.2	3.5	2.9	2.1	.37	0
Oct	4.0	3.2	2.8	1.8	.34	0
Nov	4.9	4.1	3.2	2.2	.42	0
Dec	5.0	4.2	3.4	2.2	.43	0
Total	50.1	43.0	36.7	24.2	4.54	0
	Evapotranspiration			Recharge		
Jan	0	0	0	4.4	2.9	1.0
Feb	.2	0	0	4.3	3.1	1.2
Mar	.6	.4	.2	4.6	3.2	1.0
Apr	1.8	1.2	.6	3.4	2.0	.4
May	3.0	2.2	1.1	2.7	1.0	.2
Jun	4.1	3.0	1.4	1.8	.2	0
Jul	4.8	3.2	1.0	2.1	.3	0
Aug	4.3	3.1	1.5	2.5	.4	0
Sep	3.2	2.3	1.1	2.9	.7	0
Oct	2.1	1.5	.6	2.8	1.2	0
Nov	1.0	.7	.4	4.2	2.9	0
Dec	.2	.1	0	4.9	3.6	1.3
Total	24.9	17.8	8.8	37.0	20.7	5.6

estimates of runoff, it was expected that previous studies would generally be lower than corresponding estimates of the model, since the former were based on measured stream flows whereas the model attempts to estimate both stream and diffuse runoff.

TABLE 8

Comparison of Previous Work to Model Results

Site	Area (sq mi)	Source	Estimated Quanity (MGD/sq mi)	Cornell/CES Estimated (MGD/sq mi)
Net Recharge				
Huntington, Smithtown	146	Lubke (1964)	1.01	1.00
Nassau, Wester & Central Suffolk	760	Franke & McClymonds (1972)	1.03	1.12
Babylon, Islip	190	Plukowski & Kantrowitz (1964)	1.13	1.05
Nassau, Western & Central Suffolk	760	Cohen et al. (1968)	1.08	1.12
Nassau	291	Greely & Hansen (1971)	.69	.99
Nassau and Suffolk	1166			.91
			Quantity (in/yr)	
Runoff				
Nassau, Western & Central Suffolk	760	Franke & McClymonds (1972)	.55	3.09
Nassau, Western & Central Suffolk	760	Cohen et al. (1968)	.55	3.09
Babylon, Islip	190	Pluh & Kant (1964)	1.0	5.29
East Meadow	5.6	Seaburn (1969)	9.8	
Nassau and Suffolk	1166			4.54

The nitrogen model is currently being developed and it is therefore premature to discuss any results produced by it. However, it is possible to make a preliminary overall assessment of the total possible loadings of nitrogen which may lead to contamination of the ground water. The major sources of nitrogen may be summarized in the following equation.

$$PN = W_p + F_a + F_t + 0$$

where: PN = potential loads of nitrogen which may leach to ground water

W_p = nitrogen in wastewater from the population

F_a = nitrogen applied in fertilizer to cropland

F_t = nitrogen applied in fertilizer to turfgrass

0 = all other sources of nitrogen.

All these terms can now be estimated. For example, $W_p \approx 20{,}000$ tons and $F_a + F_t \geq 10{,}000$ tons. However, the more relevant equation for assessing the contamination of ground water by nitrogen is that which estimates the actual load:

$$AN = \lambda_1 W_p + \lambda_2 F_a + \lambda_3 F_t + \lambda_4 0$$

where: AN = actual load of nitrogen leached to ground water and

λ_1 = the fraction of source which actually leaches.

It is now possible to estimate AN. λ_1 depends on the policies governing wastewater management, i.e., discharge to the marine bays, or treatment by septic tanks. λ_2 is a function of the amount of nitrogen removed by the crops. λ_3 it is believed is almost equal to 1. It follows therefore, that the actual loads of nitrogen originating from the population and from fertilizer on Long Island, are very close in magnitude as previously suggested.

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DISCUSSION

During the discussion, a questioner asked what the consequences would be for a potato crop if less nitrogenous fertilizer were applied to safeguard the quality of ground water. According to Mr. Porter, results obtained by the Cornell Long Island Vegetable Research Farm suggest that there is little, if any, significant reduction in yields.

A parallel question was asked with respect to turf. In reply, it was indicated that we have little knowledge regarding the effect on the quality of grasses if less nitrogen is applied to reduce losses to ground water. Admittedly, householders with garden lawns and golf course managers might be reluctant to accept a possible reduction in the quality of their turf.

In discussing the more general economics of fertilizer use, it was indicated that hitherto nitrogenous fertilizers have been very inexpensive relative to other costs, and hence the farmer has had little incentive to take into consideration the environmental impact of the use of the nitrogen. Also, farmers are usually unwilling to go into the fields more than they regard as being absolutely necessary. Hence, they prefer to make one large application of nitrogen rather than less, applied more frequently in accordance with the actual requirements of the crop. The one application may be deliberately excessive to allow for leaching during the period when the crop is not utilizing the nitrogen fully.

Concerning pesticides, it was pointed out that some of the newer pesticides, such as herbicides which are water soluble, may have lower mammalian toxicities than the insecticides, such as Aldicarb and carbofuran. Field work currently being undertaken in the Long Island 208 program is attempting to determine whether or not Aldicarb is present in ground water.

URBAN LAND USE PRACTICES:

POLICY IMPLICATIONS

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We are here to discuss public policy on ground-water quality protection, and my assignment is to comment on the policy implications of urban land use practices.

Traditionally, a land use plan was set forth on a map, and it depicted in yellows, purples, blacks, greens, and browns what it would all look like when everything was built. It was an end-state plan.

More and more, I think, planning agencies are getting away from the end-state planning idea and are looking at planning as new development in stages, with an eye on the public purse and the public costs of development. At the same time, established urban places want to preserve, maintain, and restore their older, developed areas. This preservation is expressed not only in physical, bricks-and-mortar terms, but also in terms of social values, convenience, and access to the broad range of public services and facilities.

In my view, there are six specific influences that have brought about this change. Most of these were initiated at the federal level, but were brought to life and positively applied at the local level.

First, new understandings have come to the locals from the realization of the real and undisputable costs of sprawl. A monumental piece of research on the costs of sprawl was published in 1974, having been sponsored by the President's Council on Environmental Quality, the Department of Housing and Urban Development, and the U.S. Environmental Protection Agency.

Second, there has grown up a considerable literature and practice around the management and control of urban growth--by the governments who have, and will, experience growth.

The third potent influence on land use planning was the passage by the Congress of a whole spate of environmental and resource control legislation: the National Environmental Policy Act of 1969, the Clean Air Act of 1970, the Water Pollution Control Act Amendments of 1972, and the Resource Recovery Act of 1976. These acts say that we can continue to live and grow in this country, but we have to do it much more carefully.

Fourthly, the last decade has seen a vast expansion in the organization of areawide councils of local governments. Some call them regional councils. There are almost 600 of them around the country now. In the early '60's there were but a handful. These regional councils plan and direct programs dealing with the urban environment that is shared by the various local governments.

Fifthly, more and more states are getting into and becoming concerned with the condition of the urban scene, as these states are increasingly being called upon to pay greater shares of urban services.

Sixth and finally, the Congress, in adopting the Housing and Community Development Act of 1974, added two requirements to be met by those who receive comprehensive planning assistance funds under Section 701 of the Housing Act. The requirements are that grant recipients must prepare a land use element and a housing element as a part of their comprehensive planning exercise.

Section 701 has been around a long time, since 1954. Last year, HUD made 701 grants to all 50 states plus 5 territories, some 500 regional councils of governments, and over 1,000 cities and counties.

HUD's land use planning regulations and guidelines provide that land use planning must be done in an environmentally sensitive manner including attention to the following factors:

1. Identify salient environmental elements; interrelationships; problems/opportunities for community development.
2. Assess factors to minimize unwise use of natural resources.
3. Recognize/allow for major latent environmental dangers/risks.
4. Make use of opportunities available (e.g., for recreation).
5. Incorporate state environmental policies/standards.

HUD now has signed agreements rationalizing the 701 comprehensive planning assistance program and its land use planning requirements with:

* EPA, Section 208 Water Quality Planning;
* EPA, Air Quality Programs;
* The Office of Coastal Zone Management, U.S. Department of Commerce;
* Economic Development Administration, U.S. Department of Commerce;
* Federal Energy Administration;
* Bureau of Outdoor Recreation, U.S. Department of the Interior;
* Bureau of Land Management, U.S. Department of the Interior.

Still pending and under negotiation is an agreement with the Department of Transportation covering:

1. Urban Mass Transportation Program,
2. Highway Planning and Research,
3. Metropolitan Highway Planning,
4. Airport Planning Grant Program.

Thus, under these inter-agency, federal-level agreements, HUD's land-use planning requirement would underlie and support some 10 other federally-financed functional facilities or environmentally oriented programs.

The most interesting thing about these six influences is what they share. They are all parts of the same phenomena. Management of growth became necessary as the costs of urban services began to get out of hand. A few years back FHA insured subdivisions, leapfrogging out along new sparkling interstate highways, brought on uneven delivery and high costs of urban services, all the way from police and fire protection to sewers and schools. These effects are known now. They now want to be avoided. All of these influences also share a concern with the environment.

I want to deal in a little more detail with what happens in areawide water-quality management planning under Section 208 of the Water Act. This is areawide planning done on an intergovernmental basis in the urban areas of the country.

Planning under the Water Pollution Control Act actually means that a region has to stage its growth. Regional planning for water-quality management requires an annually updated,five-year capital budget for sewage collector systems and treatment works. The expenditure of these funds induces and directs growth,as well as assists in meeting water quality standards.

An environmental, social, and economic impact assessment must be prepared on each areawide water-quality management plan.

The plan has dealt with water-quality influences both from point and non-point sources. The plan, in effect, implements the area's land-use plan.

I presume that the areawide land-use planning upon which basis water-quality management planning is accomplished, has been conducted in an environmentally sensitive manner. There was probably some 701 money backing up that land-use plan. It probably is environmentally sensitive in that, as areas to be developed were identified in the land-use plan, due attention and consideration were paid to the location of aquifer recharge areas, as well as the locations of wildlife habitat, steep slopes, hazardous geological conditions, and the like.

Next, in the environmental, social, and economic assessment of the plan, we come to what many call the secondary or induced impacts of water-quality management decisions. These are impacts that are largely the social and economic effects of carrying out the plan.

Should the plan provide for future growth, the questions of where, how much, and over what periods of time must be posed and addressed.

By its very nature, with a five-year financial plan annually scheduled and annually updated, the areawide water-quality management plan, as I have indicated, will cause a staging of development and, consequently, a staging or phasing of induced social and economic effects. In short, it deals with the dynamics of urbanization with timing as the crucial ingredient.

Principal among these secondary effects are the induced public investments triggered by sewering new development areas. How much for schools, fire and police protection, libraries, recreation facilities and services, streets and roads, and other elements of publicly-financed and provided infrastructure? Who is to provide, who is to pay, who is to operate, are all related questions to be posed. Are local governments to share certain costs and individually pick up other costs?

I suggest to you that, with experience, this part of the assessment exercise can provide local governments with very important new tools in the management of their fiscal affairs and in their becoming more knowledgeable concerning the consequences and costs of growth.

Finally, let me comment on planning for water-quality management as an integral part of building a continuing, areawide, intergovernmental, political decisionmaking process. The development, nurturing and strengthening of such a process can and must be a key payoff in areawide water-quality management planning. A plan developed by skilled technicians that is engineered correct in every detail, but which is outside of and absent from such a politically-based decisionmaking process, will fail. The tragedy of such an approach will be recognized when it is realized that those who pay the bills and pass the laws establishing regulatory processes will not understand the why of the proposed actions, as correct and sound as they might be.

Visible political responsibility for the proper functioning of man's environment on the part of those who are elected to govern, is one of the keystones to areawide water-quality management and its concommitant land-use planning.

Areawide planning for water-quality management planning will involve engineers working side by side with trained experts in public finance, management, and intergovernmental affairs. Knowledgeable folk in historic preservation and environmental management will be involved as well as the planner types. Water-quality management planning must address and consider matters of urban-growth management as well as the nondegradation of clean water and the cleanup of dirty water. All of these factors and concerns provide a planning team and planning program which can operate in an arena of informed, local, political decisionmaking.

You will note and recall that water-quality management planning is conducted on an areawide basis--intergovernmentally. So are many other federal programs.

Consider the following:

- * Urban Mass Transit Planning
- * Highway Transportation
- * Air Quality Maintenance
- * Solid Waste Management (new)
- * Housing

Add water quality and land use to this list and it becomes a formidable arsenal of concerns which the units of local general government, acting in concert, can apply to the shaping of their shared region.

In all cases in the above list of programs and concerns there is federal agency involvement and in most cases state involvement as well. Hence, at the regional council bargaining table, all interests that define the public interest and which act on that public interest, so defined, are represented.

The Office of Planning and Research, a part of the Governor's Office in California, published, in October of 1976, "An Urban Development Strategy for the State of California." This report and its recommendations were developed over a period of months with regular consultation from two key advisory committees:

> Urban Development Advisory Committee
> 15 members, composed of local officials, and representatives of industry, home building, labor, environment, and financial interests; and
>
> Urban Development Interagency Task Force
> 16 members representing major state departments and agencies.

The report indicates that the existing tax structure gets in the way of orderly urban development and the wise use of land in urban areas. The tax structure forces competition between jurisdictions for tax rateables such as shopping centers and industrial development.

The report also indicates that areawide councils of government are the key building blocks, the groups of locally elected officials who will have to make the intergovernmental decisions as to the region's further growth and development. The state program proposes that legislation will be developed

> ". . . directing each metropolitan Council of Governments to prepare--and regularly revise--an assessment of regional needs, consistent with the overall State policies included in this Report. To the extent possible, the needs assessment shall be set forth in quantitative terms. It shall allocate needed housing, industrial areas, transportation and public facilities and other appropriate factors required within the region among its member cities and counties. The regional needs assessment shall

be an integral part of each COG's regional plan."

Part of the state's policy indicates that state action and financial assistance would encourage the location of needed industrial and further urban development within and contiguous to existing developed urban areas.

The program then would require that each city and county comprehensive and land-use plan be adjusted annually to conform to the COG statement of regional needs. Special purpose districts would also be instructed to conform their annual budgets, covering operating and capital outlay, to the COG's Statement of Regional Needs.

What this says is that local general purpose and special purpose governments will conform to the regional COG's annual statement of regional needs. In so accepting and adjusting plans and budgets, regional land-use development is directed.

Having allocated regional land development needs between localities, the state policy then provides that:

> "Within metropolitan regions, portions of future property and sales taxes shall be fairly distributed among communities on the basis of actual need. Fiscal considerations shall not be the determining factor in a community's urban development decisions."

Within metropolitan areas, tax-sharing districts would be established to pool added increments of real property taxes, collected beyond the dates that the regional needs assessments are initially laid on. These additional real property tax collections would then be shared by municipalities within each metropolitan area on the basis of actual need.

Statewide, they propose to share sales tax increments, after a date that would freeze existing collections of sales taxes, and distribute, according to local government need, the additional tax receipts collected.

All of this may sound crazy or unusual to you here. But it is a serious series of proposals, developed with broad consultation, and out to the public now, and their organizations, for serious consideration and debate. We will see what the Governor proposes next year to the legislature after local consideration.

I have saved almost to the last some comments on the non-point source management planning requirement of the Water Pollution Control Act Amendments of 1972. Quite probably these considerations have the most direct interface with the maintenance of ground-water quality.

Around the country, we are just beginning to understand the full implications of non-point source contributions of pollutants to the quality of the streams and lakes of the nation. In the Atlanta metropolitan area, a Corps of Engineers Urban Studies Program done under the sponsorship of the State of Georgia and the Atlanta Regional Commission found in 1974 and 1975 that 45 percent of the Biological Oxygen Demand and 95 percent of the suspended solids in the region's waters comes from non-point sources--from stormwater runoff in urban areas.

In the Baltimore Metropolitan Area, they have found that the municipal water supply reservoirs are reaching a state of eutrophication. Over 75 percent of the phosphorous loads in these reservoirs comes from non-point source runoff--and there is not a sewage treatment plant or any urban settlement anywhere near the reservoirs.

I am not an expert on the hydrology of ground-water recharge. In fact, I have not found too many planners who are. As Jay Lehr said this afternoon, most Americans still believe in water witching. But I cannot but believe that management of non-point sources, quite often matters of municipal, agricultural, forestry, and construction good housekeeping, would help to maintain the quality of what gets back into the ground. Non-point source management over the long run will prove to be the most critical part of the clean water program in this country.

On the land-use planning side--to me the signs are positive. Containment of settlement, planning in an environmentally sensitive manner, respect for and protection of aquifer recharge areas, management of the runoff that flows into our streams and lakes--all these are things that have not been done on a regular and doctrinaire basis before. They are being done today.

People who are concerned with maintaining ground-water quality should directly enter and influence the land-use planning game, and its political decision-making process, and push it farther along the track that it is already traveling on.

I want to close with two quotes that mean a great deal to me. They help me understand where I am at, in the land-use planning game. The first is from David Morell, now at Princeton University and formerly head of land-use and transportation policy in EDA's Air Quality Program. Morell wrote:

> "America is blessed--and simultaneously burdened--with a fragmented, de-centralized political system based on federalism, home rule, and local autonomy. Although federal political power has expanded substantially, and seemingly inexorably, over the past decades, decisions on growth and land use have remained the dominant province of local government. Thus, decision-making regarding the public policy interface between the boundaries of political entities and environmental areas (e.g., air basins), and incongruity between planning--for land use, for air quality, for both--and subsequent implementation of such plans. Federal and state governments make the basic air pollution control decisions under the Clean Air Act of 1970; yet thousands of local municipalities make the multitude of daily land use decisions which determine, in the aggregate, the spatial and temporal patterns of national development. These local land use decisions, in turn, have a direct influence on air quality, not only in the immediate vicinity of the

project but often for miles around.

> "The key to understanding American political institutions involved in land use, transportation and air quality lies in analysis of land use decision-making as opposed to land use planning. On balance, we already have a sufficient amount, if not a surfeit, of land use planning, of course. But the glaring lack is for land use decisions to reflect these plans, to be cognizant of the air quality impact of new facilities and of new patterns of automobile traffic."[1]

The second quote is from Peter Drucker who ties long range planning to the making of decisions in the present and the commitment of resources:

> "Decisions exist only in the present. The question that faces the long-range planner is not what his organization should do tomorrow. It is: What do we have to do today to be ready for an uncertain tomorrow? The question is not what will happen in the future. It is: What futurity do we have to factor into our present thinking and doing, what time spans do we have to consider, and how do we use this information to make a good decision now?
>
> "Decision-making is essentially a time machine which synchronizes into one present a great number of divergent time spans. This is, I think, something which we are only learning now. Our approach still tends toward the making of plans for something we will decide to do in the future. This may be a very entertaining exercise, but it is a futile one.
>
> "The test of a plan, in other words, is not how good the plan is itself. The test is whether management actually commits resources to action which will bring results in the future. Unless this is being done, there is no plan. There are only promises and hopes."[2]

This is where land-use planning lies today--we are trying to make it work in a federal system with many inhibitions and directives built in, and we are trying to position it so that it commits resources in the real world and protects and enhances our environment at the same time.

FOOTNOTES

1. Princeton University, Center for Environmental Studies, Report No. 33, August, 1976.

2. Drucker, Peter F., "Long Range Planning Means Risk Taking." Long Range

Planning for Management. Ewing, David W., Ed. New York: Harper and Row, 1972, p. 7.

DISCUSSION

The discussion can be related to two general issues: the level of ground-water quality desired and the irrigation return-flow problem.

It was noted that the issue of what level of ground-water quality is desired is a fundamental management question but that little consideration had yet been given to this issue. High-quality ground water was viewed as having value, but value was viewed as a relative matter depending on the facts of the individual case. A second aspect of this issue is the question of whether certain land and water areas should be dedicated solely for waste disposal purposes. Support was given to the dedication concept, but it was noted that an open expression of this philosophy was not politically acceptable at present.

The basic question regarding the return flow issue was whether any control method exists which is environmentally satisfactory but which also possesses technical, economic, and political feasibility. It was stated that the California water quality management agency referred to in the paper has traditionally ignored the problem but that a comprehensive look at alternative control strategies is desirable.

LAND APPLICATION OF WASTEWATER AND RESIDUALS:

POLICY IMPLICATIONS

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The natural environment consists of many elements constantly acting and interacting with each other. It is a dynamic, ever-changing system that has undergone over 4 billion years of stresses and dramatic changes. The environment must respond to constant stresses from natural phenomena, such as rainstorms, tornadoes, drought, fires. When a segment of the environment cannot change with or adapt to these stresses, it is eliminated.

Recently in the earth's history (i.e., the last 4 million years), there appeared on the landscape a new animal--man--who has applied unforeseen stresses to the environment. To these impacts, the environment has changed and adapted. In response to heavy smog in England during the 1800's, for example, there was a change in the coloring of several species of birds. Adaptation is a necessity for survival; without it, the animals disappear as did the dinosaurs and the Moa birds in New Zealand.

It is a recognized fact that any function of man will alter the environment. This earth has been both used and abused by mankind. However, as we understand the elements of the environment and recognize the impacts that man is having upon them, it becomes possible to manage these elements for the benefit of mankind. Such benefits can be short-term, such as in the one-time extraction of minerals, or long-term, such as through the use and reuse of water.

Within the ever-changing environment, one of the most common and most necessary resources is water. Unfortunately, it is also an abusable resource. Farming to produce crops for food has resulted in erosion of the topsoil, sedimentation of the streams, turbidity in the lakes and rivers, and alteration of the aquatic and hydraulic balances. Farming is a necessity for the survival of the human race, but farming can be accomplished without excessive sedimentation. We now have the techniques at hand to effect this. Where these techniques are intelligently applied, there will be an improvement in water quality. Where the techniques are not applied, there will be a destructive impact on water quality. Mankind must recognize that he will always affect water quality in his daily activities. The degree of that effect can vary drastically.

I would like to distinguish between two degrees of effect. Two words that have commonly been used to describe mankind's effect on the environment are contamination and pollution. For this evening, I would like to distinguish between these two by defining contamination as a water-quality change in which the resulting water is still useable, whereas pollution is a water-quality change resulting in water of reduced quality such that it is no longer useable. Although other phrases can be used to make these distinctions, it is important that these degrees of effect be recognized. Any activity of mankind, including waste disposal, will result in contamination and should not result in pollution.

In the 1950's and 1960's there was a growing concern about the quality of surface waters in the United States. The discharge of untreated or partially treated wastewaters into the surface waters was causing significant pollution. Public outcry was heard, and policy developed on the federal and state levels to require treatment and/or a higher degree of treatment for sewage, industrial waste, and hazardous waste being discharged to the surface waters.

The progressively stringent quality goals set by the state and federal governments for the discharge of wastewaters into receiving streams made the alternative of land disposal particularly appealing to municipalities and industries. While the state regulatory agencies were concerned with developing and implementing programs to abate discharges of wastewaters into receiving streams, they were ignoring land-disposal practices. This was due either to an unawareness of the potential impact on ground water or to the pressing program needs to improve the quality of surface waters. At any rate, uncontrolled land application of wastes caused significant local ground-water pollution problems. For example, in the mid 1960's, partially treated hazardous wastes were spray-irrigated onto the ground in central Pennsylvania. This area is underlain by limestone, and the wastes polluted the underlying ground water as well as several nearby springs, and degraded a nearby stream into which the ground water discharged. At that time, the state regulatory agency had no program to require a permit for land disposal of wastewater.

Public policy toward land application of wastewater and ground-water quality moved forward almost on a case-by-case basis. The requirement for permits from regulatory agencies has been non-existent or, at best, has called for only a rudimentary submittal of information as to the suitability of the site and the probable impact on the underlying ground water.

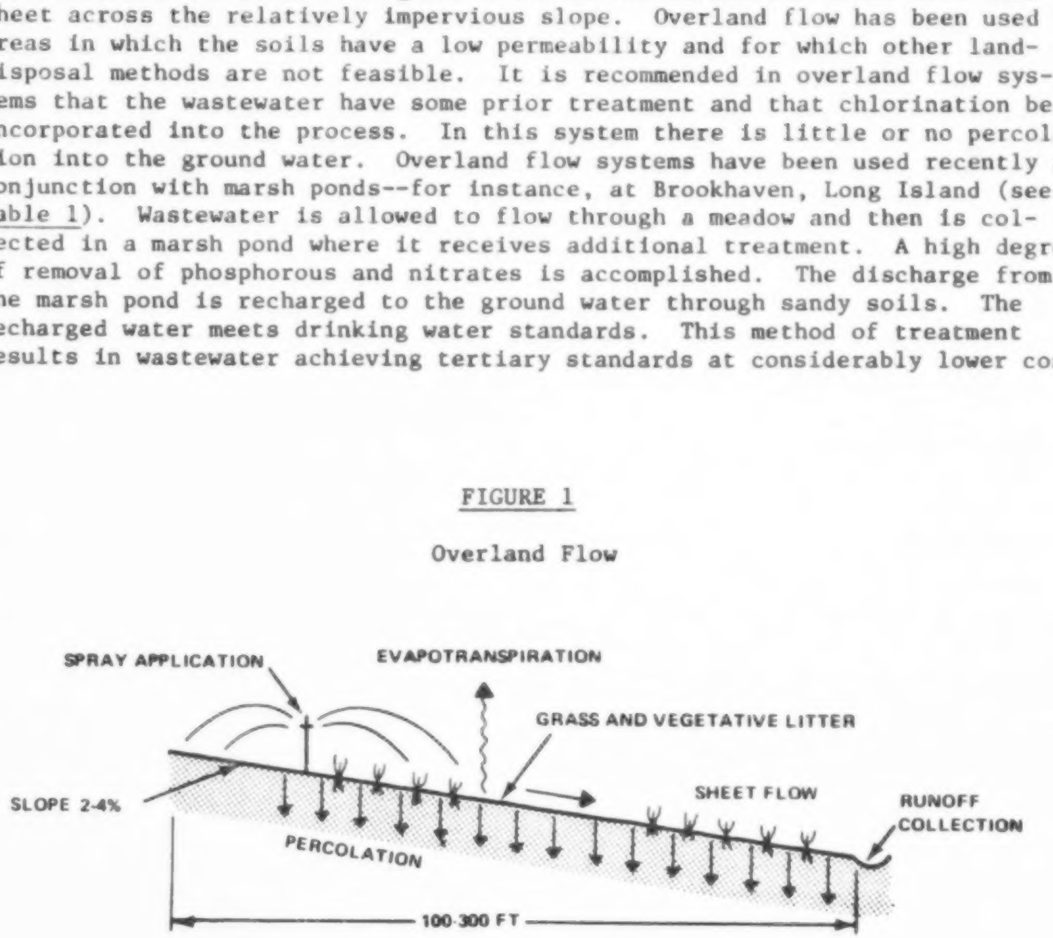
The passage of the Federal Water Pollution Control Act Amendments in 1972 (P.L. 92-500) has had a significant impact on the acceptance of land disposal of wastewaters. Section 201 of that legislation requires the study of alternative waste-management techniques, including land application, for the best practical waste-treatment technology (BPT). It encourages recycling of wastewater and treatment system management that combines open space and recreational considerations. In addition, Section 208 allows 75 percent reimbursement for the acquisition of land to be used in wastewater disposal systems. Recent decisions by the U.S. Environmental Protection Agency have extended this grant money to leasing of land for land application systems. P.L. 92-500 proposes to eliminate the discharge of pollutants into navigable waters by 1985. One of the alternatives through which this goal can be met is treatment by land application. All planning for wastewater treatment systems funded by the federal government must include alternative methods. Where these alternative methods are found to be cost-effective, they must be implemented.

Suddenly, the push is on for land application of wastewater. Eutrophication of lakes and enrichment of streams from the nutrients in treated wastewater have encouraged land application. The economic advantage of secondary treatment with land application, as against tertiary treatment and nutrient removal, has also stimulated the use of land application systems.

The three basic methods of land application are (1) overland flow, (2) infiltration-percolation, and (3) irrigation. Overland flow is essentially a biologic treatment process in which the treated wastewater is applied to the upper reaches of the slope, and allowed to flow across the vegetated surface to runoff collection ditches (see Figure 1). Renovation is accomplished by physical, chemical, and biological means as the wastewater flows in a thin sheet across the relatively impervious slope. Overland flow has been used in areas in which the soils have a low permeability and for which other land-disposal methods are not feasible. It is recommended in overland flow systems that the wastewater have some prior treatment and that chlorination be incorporated into the process. In this system there is little or no percolation into the ground water. Overland flow systems have been used recently in conjunction with marsh ponds--for instance, at Brookhaven, Long Island (see Table 1). Wastewater is allowed to flow through a meadow and then is collected in a marsh pond where it receives additional treatment. A high degree of removal of phosphorous and nitrates is accomplished. The discharge from the marsh pond is recharged to the ground water through sandy soils. The recharged water meets drinking water standards. This method of treatment results in wastewater achieving tertiary standards at considerably lower cost,

FIGURE 1

Overland Flow



Source: U.S. EPA Technology Transfer. Land Treatment of Municipal Wastewater Effluents. Vol. 1, Design Factors. p. 4.

TABLE 1

Brookhaven Marsh Pond (Overland Flow)

	Raw Wastewater (Average)	Discharge from Marsh Pond (Average)
BOD	148	18
COD	427	56
Total N	25	10
Total P	7.2	2.2

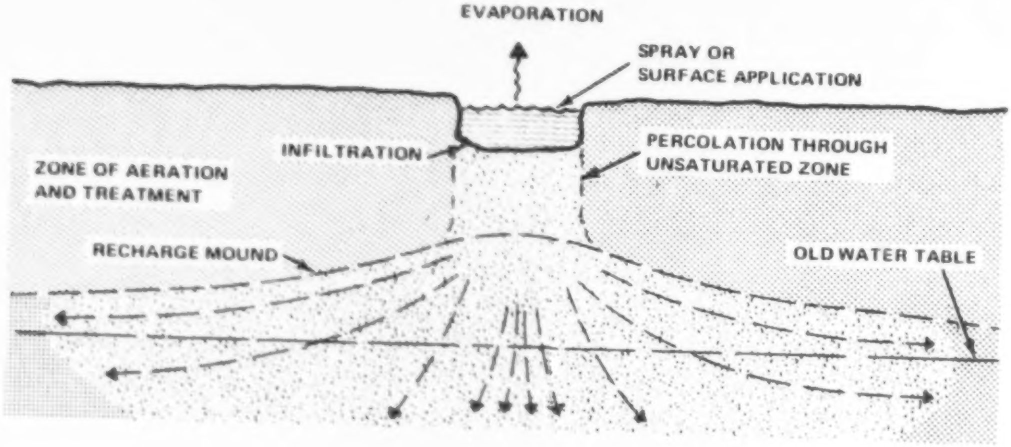
Source: Small, 1976

with generation of minimal or no sludges. In addition, because there is minimal percolation to the subsurface, this method can be used on lands that are unsuitable for other methods of land application due to low permeability of the underlying soils. It is recommended that state policy require monitoring of the subsurface waters to insure proper operation and no ground-water pollution.

In the infiltration-percolation system, effluent is applied at high rates to spreading basins in permeable deposits (see Figure 2). This system has been used in the arid southwest. The Flushing Meadows Project in Phoenix, Arizona, discharges approximately 80 million gallons per day of effluent from activated sludge plants into infiltration basins (see Figure 3). The basins are filled to a depth of one foot and are flooded for periods of 20 days, alternated with drying periods of about 10 days in the summer and 20 days in the winter. At these rates, three to four acres of infiltration basin are required for each mgd of effluent. The basins are underlain by three feet of fine, loamy sand and 250 feet of sand and gravel. The average nitrogen content of the effluent is 30 ppm, almost all in the form of ammonia. Annual nitrogen loading is 30,000 pounds per acre per year, and most nitrogen removal is by biodenitrification in the soil produced by flooding and drying periods (see Figure 4). Nitrogen removal, observed at a well located in the middle of the basin area at a depth of 30 feet (which is 20 feet into the ground water), varied from 30 percent during periods of flooding to nearly 90 percent during drying periods. The ammonia nitrogen is converted to nitrate nitrogen, which moves down into the underlying ground water. Phosphate concentrations in the wastewater were approximately 10 milligrams per liter; renovated wastewater contained 50 percent less phosphate. In a well 100 feet away from the basin area, a 90 percent reduction in phosphate was observed.

FIGURE 2

Infiltration-Percolation


EVAPORATION
SPRAY OR SURFACE APPLICATION
INFILTRATION
PERCOLATION THROUGH UNSATURATED ZONE
ZONE OF AERATION AND TREATMENT
RECHARGE MOUND
OLD WATER TABLE

Source: U.S. EPA Technology Transfer. Land Treatment of Municipal Wastewater Effluents. Vol. 1, Design Factors, p. 4.

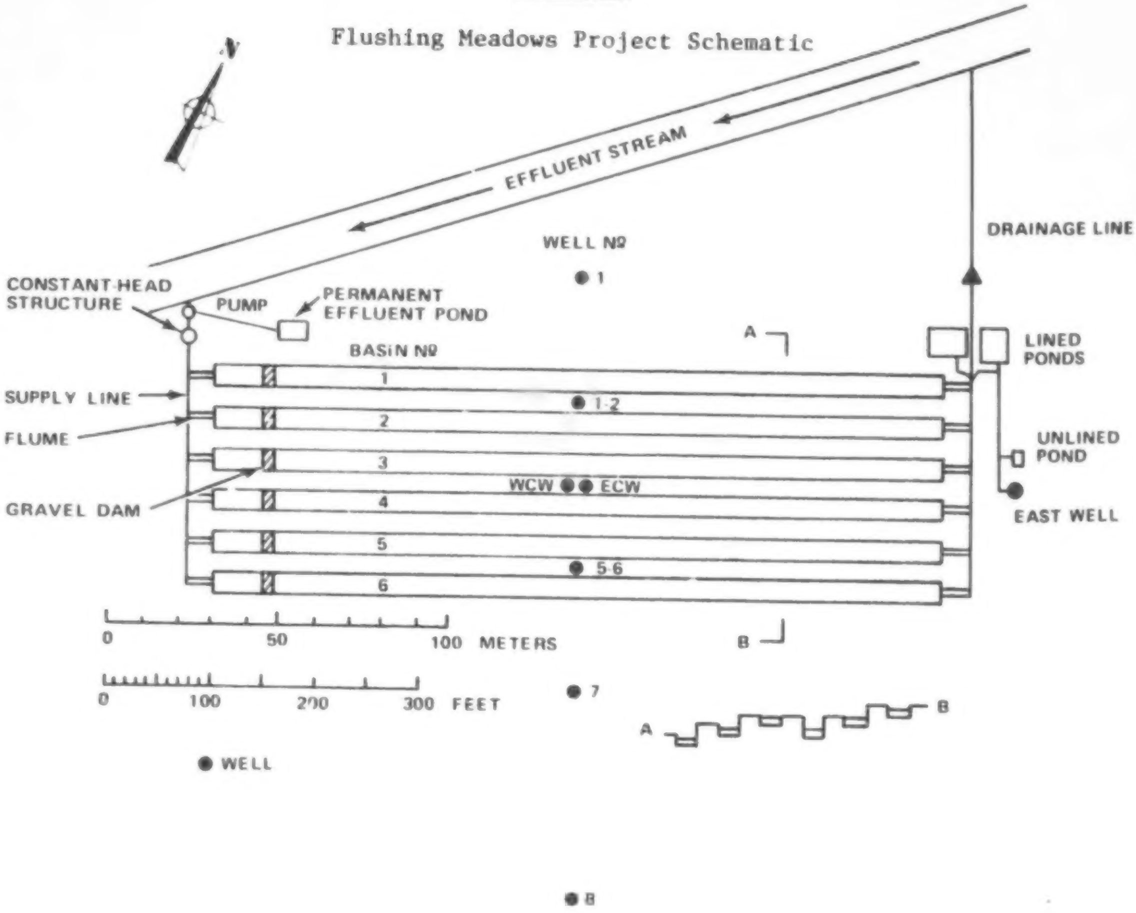
Spray irrigation is the predominant application method used today. It involves the application of effluent to the land for treatment and as a means of returning necessary nutrients to plants (see Figure 5). The applied effluent is treated by physical, chemical, and biological means as it seeps through the soil into the underlying ground water. Once in the ground water, quality changes are the result primarily of dilution. Spray irrigation has the following advantages: (1) a high degree of treatment to remove nutrients from effluent; (2) the economic return of the nutrients to produce marketable crops; (3) ground water recharge, and (4) the preservation and maintenance of open space.

The primary consideration in selecting a site for spray irrigation is the prevention of adverse effects to surface and ground-water quality. The criteria to be evaluated include the soils, geology, and ground-water conditions at the proposed site. The major renovation of wastes takes place in the upper few feet of the soils where the biologic activity is most important. Well-drained, deep loamy soils are preferable for spray irrigation. Extremes such as sandy, gravelly, clayey, or stoney phases are rarely acceptable. Soils should not have a fragipan or a seasonally high water table.

The four major geologic factors to be considered are structure, weathering, lithology, and the presence of glacial deposits. These factors will affect the direction, rate, and renovation afforded to the spray irrigated waters.

FIGURE 3

Flushing Meadows Project Schematic


N
EFFLUENT STREAM
DRAINAGE LINE
WELL Nº
1
CONSTANT-HEAD STRUCTURE
PUMP
PERMANENT EFFLUENT POND
A
LINED PONDS
BASIN Nº
1
2
3
4
5
6
SUPPLY LINE
FLUME
GRAVEL DAM
1-2
WCW
ECW
5-6
UNLINED POND
EAST WELL
0
50
100 METERS
0
100
200
300 FEET
B
7
A
B
WELL
8

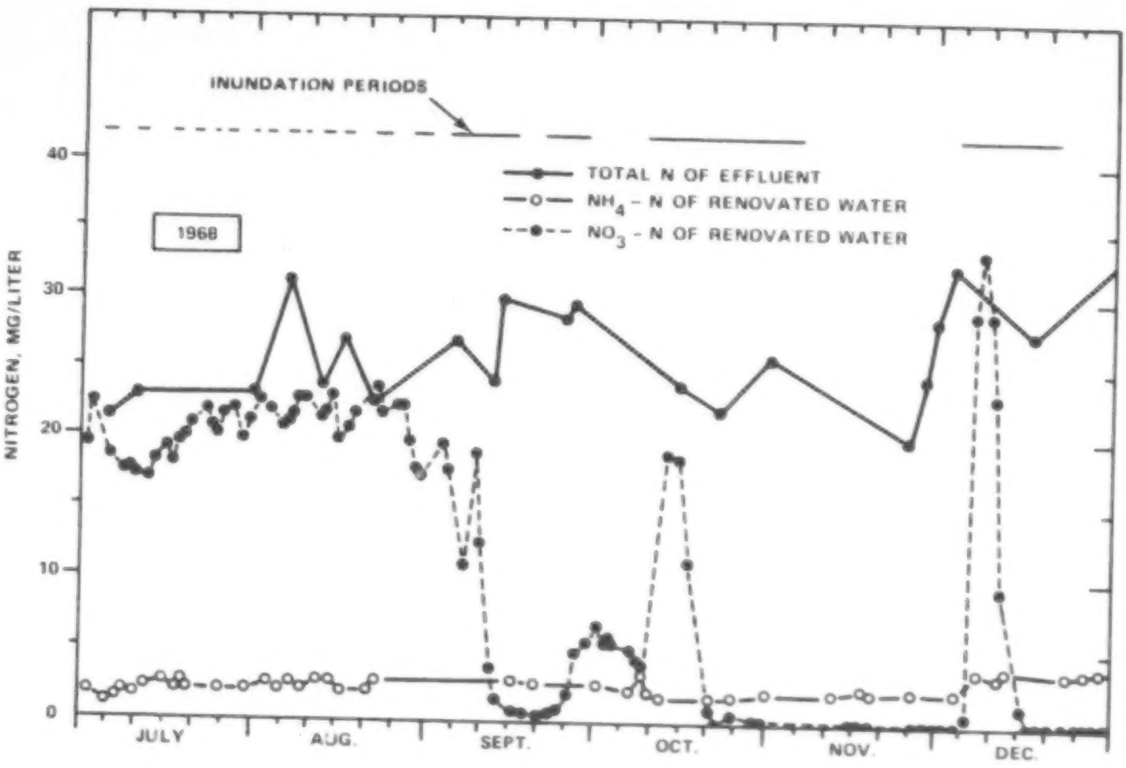
Source: U.S. EPA Technology Transfer. Land Treatment of Municipal Wastewater Effluents. Vol. 3, Case Histories. p. 30.

Hydrologic criteria for site selection include the depth to ground water, the rate and direction of ground-water movement, location of natural ground-water discharge points, and the potential for ground-water mounding and its effect on the renovative capacity of the system. Care must be taken to insure that the development of the ground-water mound does not significantly change the rate and direction of ground-water movement from the site. The seasonal high water table should be at a depth of approximately 10 feet.

Penn State University, since 1963, has had an extensive program of spray irrigating 500,000 gallons per day of secondarily treated, chlorinated wastewater onto woodlands and crop lands. From this program has developed the concept of the "living filter." This has dramatized the positive benefits of spray irrigation; tree and crop yields have increased significantly with a

FIGURE 4

Flooding Impact in Nitrogen Levels
in Secondary Sewage Effluent and Renovated Water



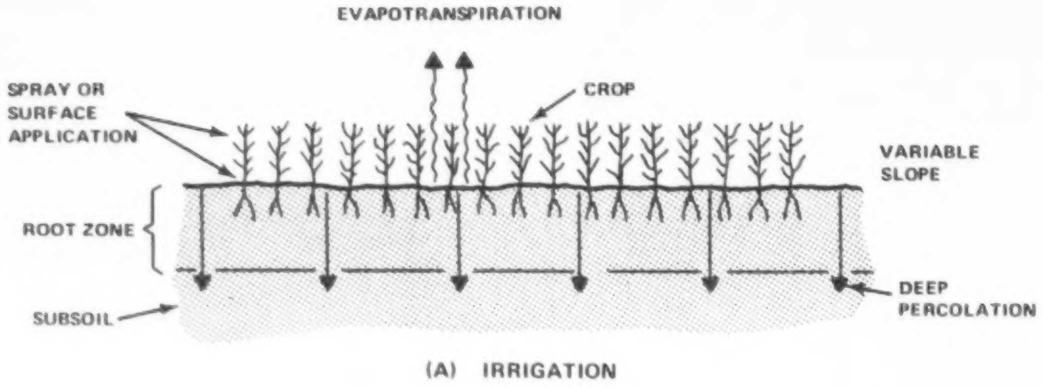
Source: U.S. EPA Technology Transfer. Land Treatment of Municipal Wastewater Effluents. Vol. 3, Case Histories, p. 32.

concurrent increase in recharge to the ground water. In fact, the spray field locations were selected to be upgradient from the university well field in order to maximize the benefits of ground-water recharge (see Figure 6). Nutrient removal is accomplished in the upper six inches of the soil (see Table 2).

A small retirement community in southeastern Pennsylvania has been operating a spray irrigation system for its wastewater since October of 1973. Approximately 30,000 gallons per day are generated and sprayed on four acres in

FIGURE 5

Irrigation



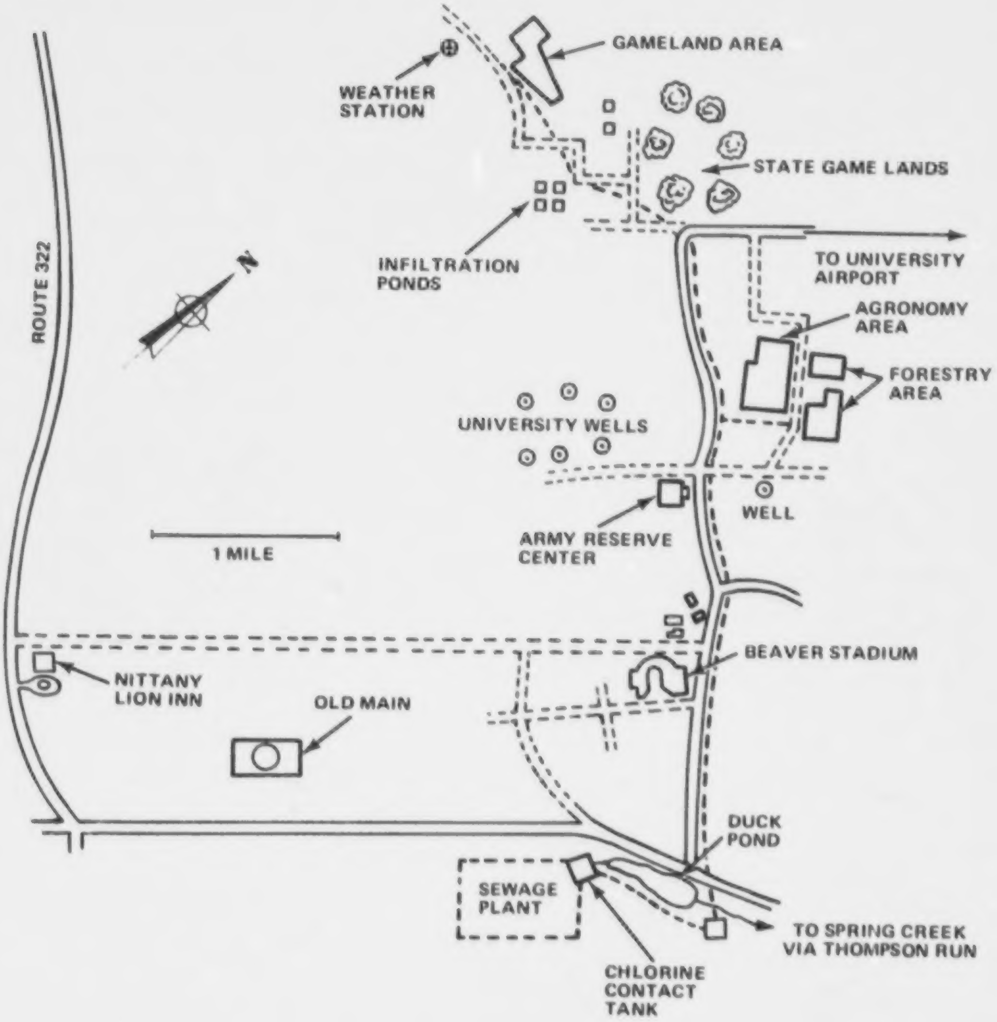
Source: U.S. EPA Technology Transfer. Land Treatment of Municipal Wastewater Effluents. Vol. 1, Design Factors, p. 4.

woodland at a rate of two inches per week. Wastewater is treated in an oxidation pond with a floating aerator. Treated wastewater is stored for up to 20 days in the pond, chlorinated, and then spray-irrigated onto the woodlands within 75 feet of the private residences. Chemical analyses of monitoring wells in the ground water indicate that changes in water quality have been variable but relatively insignificant (see Table 3). There has been a minor increase in chloride and no definite trend in nitrate concentrations.

The Muskegon, Michigan, sewage irrigation project has received much public attention (see Figure 7). It has shown that a large population can be served successfully by a land-application system, when it is properly designed and operated to meet existing field conditions. The present flows are approximately 28 million gallons per day; the 1992 design flow is 42 million gallons per day. The wastewater is biologically treated in three aerated lagoons. Each lagoon has eight acres of surface area and a holding capacity of 42 million gallons. The treated wastewater is discharged into two large storage lagoons covering a total area of 1,700 acres, with a capacity of 5.1 billion gallons. Additional treatment of the wastewater is attained in these storage lagoons. Wastewater is chlorinated with a minimum contact time of 29 minutes. Using center pivot rigs, the wastewater is sprayed onto 6,000 acres at an application rate of 3.8 inches per week for an eight month period. Groundwater depths of less than five feet were found in the spray fields and subsurface drain tiles were installed. One section is also drained by wells. The quality of the ground water coming from the drain tiles meets drinking water standards (see Table 4).

FIGURE 6

Pennsylvania State Wastewater Renovation and Conservation Research Project


GAMELAND AREA
WEATHER STATION
STATE GAME LANDS
INFILTRATION PONDS
ROUTE 322
N
TO UNIVERSITY AIRPORT
AGRONOMY AREA
FORESTRY AREA
UNIVERSITY WELLS
WELL
ARMY RESERVE CENTER
1 MILE
BEAVER STADIUM
NITTANY LION INN
OLD MAIN
DUCK POND
SEWAGE PLANT
TO SPRING CREEK VIA THOMPSON RUN
CHLORINE CONTACT TANK

Source: U.S. EPA Technology Transfer. Land Treatment of Municipal Wastewater Effluents. Vol 3, Case Histories, p. 39.

TABLE 2

Penn State
Spray Field Nutrient Removal (mg/liter)

	Treated Wastewater	Suction lysimeter* depth		
		6"	24"	48"
Phosphorous	3.490	0.161	0.067	0.038
Nitrate-N	4.9	1.2	0.8	2.4

*Reed canarygrass area.
Loading 2" week.

Source: Sopper and Kardos, 1973.

Treatment of wastewater by conventional systems generates significant amounts of residuals or sludges. The requirements for tertiary treatment involving chemical/physical processes will increase sludge generation up to sixfold. In the past, much of the sludge has been disposed of by incineration. Increasing fossil-fuel costs make this a very expensive part of the wastewater treatment operation. There has been a recent movement to increase the amount of residues that are disposed of onto the land. The Metropolitan Sanitary District of Greater Chicago began transporting digested sludge to Fulton County, Illinois, for land disposal in the early 1970's. In addition, many smaller communities have in the past utilized land disposal of partially digested or digested sludges. This is most common where there is significant farm land available and farmers are willing to use the sludge for its soil conditioning and nutrient benefits.

Public policy or concern for land disposal of sludges has been minimal except for such larger projects as those in Chicago, Washington, and Philadelphia. Wastewater treatment facilities in the larger municipalities handle a combination of sewage and industrial wastes. Sludges from these waste streams can contain appreciable amounts of heavy metals and care must be exercised in their land application. These metals can be mobilized and percolate down into the underlying ground water. In other cases, the metals will be taken up by crops and can be passed on to animals or human beings. Regulatory response for residue disposal has followed along lines similar to that of land application of wastewater.

Although no distinct policy on ground-water quality protection from land application has yet been articulated, the existing state policies can be assessed when reviewing the operation of land-disposal systems. The Colorado

TABLE 3

Ground-Water Quality (mg/liter), Kendall at Longwood

Well No.	Location	1974 Cl	1974 NO_3	1976 Cl	1976 NO_3
1	Background	6.0	2.85	-	-
2	Downgradient	5.0	0.35	8.1	0.19
3	Downgradient	7.5	0.80	11.4	3.62
4	Downgradient	7.0	-	7.4	0.628

Source: Records supplied by Kendall at Longwood.

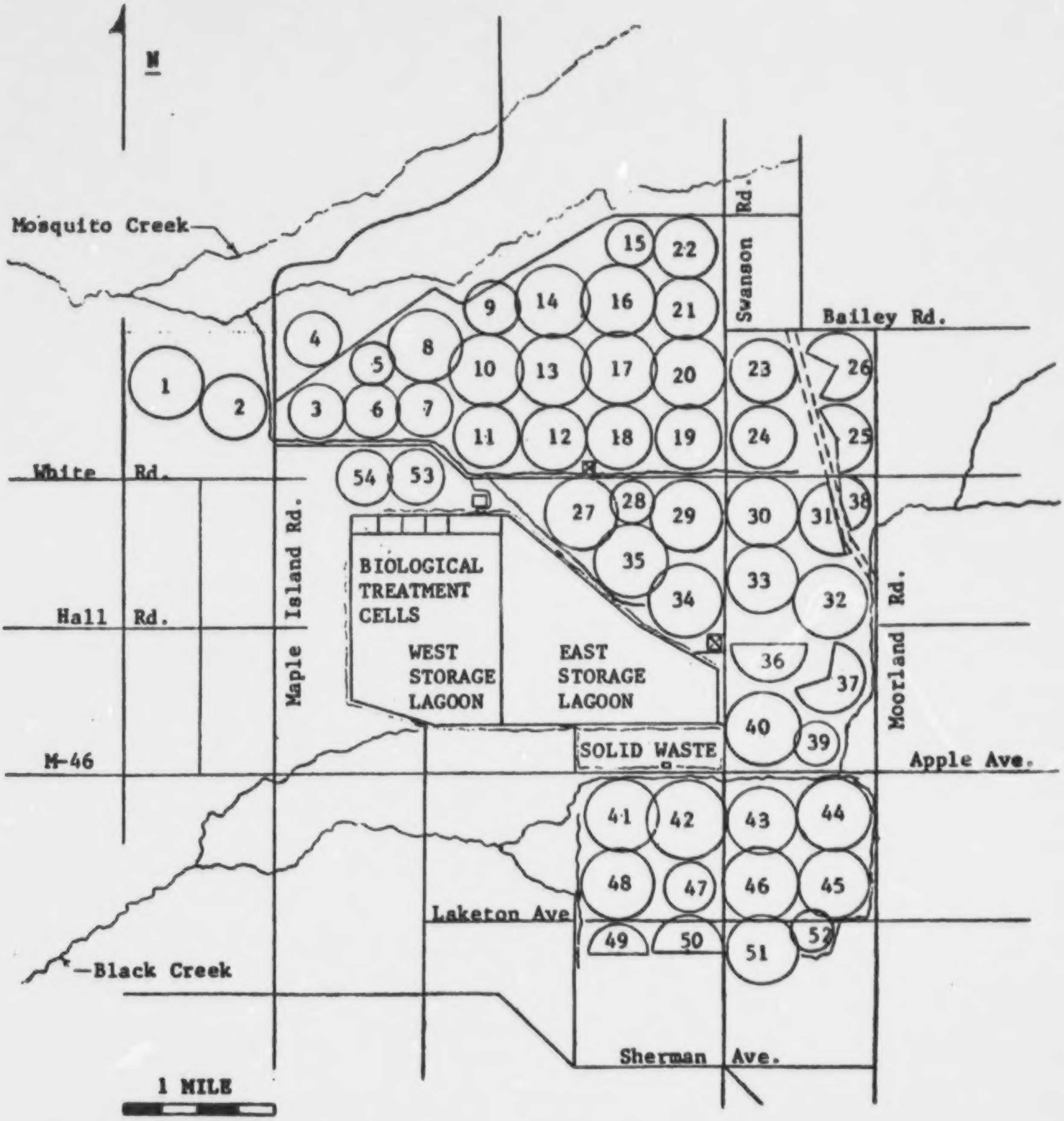
Water Quality Control Commission's policy encourages land treatment of wastewater for numerous environmentally sound reasons, many of which are to protect surface-water quality. An EPA document, Alternate Waste Treatment Techniques for Best Practical Waste Treatment, states:

> "Any land application or land utilization technique must, in order to qualify for federal funds, comply with criteria designated to protect groundwaters. These criteria are intended to insure that the nation's groundwater resources remain suitable for drinking water purposes."

If this policy is implemented by EPA, land disposal and ground-water quality must be considered together. A critical point is the decision as to where the ground-water system will be sampled for monitoring. In surface water, the treated effluent is discharged into the receiving body of water. It has been established that below this point of discharge is a mixing zone. Mathematical modeling of this zone and the water quality within the zone have been established by the Streeter-Phelps equation and all succeeding modifications. In the ground-water system, we are faced with a similar decision: Shall the ground-water quality standards be established immediately below the point of land application, or shall a mixing zone be established similar to that of surface waters? Unless a mixing zone is allowed for ground-water discharges, many land-treatment systems may be eliminated from consideration. Also, in areas where the upper ground water does not meet drinking water standards and is hydraulically isolated from suitable water in lower aquifers, should land application be prohibited because of a small increase in mineral content? Ground-water standards are needed to ensure that sufficient treatment is provided and that the ground water is not drastically altered in quality. But

FIGURE 7

Muskegon County Wastewater Management System No. 1


N
Mosquito Creek
Swanson Rd.
Bailey Rd.
White Rd.
Maple Island Rd.
Hall Rd.
BIOLOGICAL TREATMENT CELLS
WEST STORAGE LAGOON
EAST STORAGE LAGOON
Moorland Rd.
SOLID WASTE
M-46
Apple Ave.
Laketon Ave
Black Creek
Sherman Ave.
1 MILE
1
2
3
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12
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Source: Demirjian, 1975, p. 11.

ground-water standards must be developed realistically. Land application will cause contamination, but rational standards must not allow pollution of safe drinking water.

TABLE 4

Drainage Water Quality

Parameter or Constituent	Drain Tile	North Outlet	South Outlet
BOD_5, mg/l	< 1	4	4
COD, mg/l	NA	35	25
SS, mg/l	NA	5-20	30
Ammonia nitrogen, mg/l	0.1	0.5	0.5
Nitrate and nitrite nigrogen, mg/l	3	0.6	0.7
Total Kjeldahl nitrogen, mg/l	0.1	1.4	1.2
Orthophosphate, mg/l	ND-0.04	ND-0.25	ND
Total phosphorus, mg/l	NA	ND-0.2	ND
Fecal coliform, mpn/100 ml	< 1	NA	NA

Source: Sanks and Asano, 1976, p. 299.

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DISCUSSION

The two major issues discussed involved determination of the point to measure ground-water quality in relation to the source of pollution and the need for chlorination prior to land application of wastewater.

With regard to the issue of where to measure quality, one suggestion was the boundary of the property on which the pollution occurs. Another suggestion was to allow the polluter and the downgradient landowner to reach any agreement concerning alteration of ground-water quality acceptable to both. However, problems with these approaches include difficulties of predicting movements of contaminated water and the question of future changes in property ownership. Consideration was also given to the question of what constitutes "pollution." The view was expressed that limitation of the term to alterations in quality that precluded other uses would provide management flexibility.

The discussion of the need for chlorination of wastewater to be applied to land noted that standard practice included this step but that the actual need was subject to question. The requirement imposed by some states that the same treatment be given as in the case of discharge of effluent to surface water was viewed as wasteful. It was noted that agricultural wastes are often applied to the land with no treatment. However, the question of possible virus problems creates sufficient uncertainty to prevent an easy answer. There apparently is no evidence of virus problems where secondary treatment and chlorination have been employed. It was resolved that the issue is compounded by difficulties associated with investigations involving viruses, but there is need for better information.

Implementation of Controls

THE UNDERGROUND INJECTION PROGRAM
UNDER THE NATIONAL SAFE DRINKING WATER ACT

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Approximately half of all Americans take their drinking water from underground sources. Questions as to the future safety of existing and potential water supply aquifers was one of the principal concerns voiced by Congress in the passage of Public Law 93-523, the National Safe Drinking Water Act in December of 1974.

The purpose of the legislation is to assure that water-supply systems serving the public meet minimum national standards for the protection of public health. The Act is designed to achieve uniform safety and quality of drinking water in the U.S. by identifying contaminants and establishing maximum acceptable levels. Prior to this Act, the Environmental Protection Agency was authorized to prescribe federal drinking water standards only for water supplies used by interstate carriers. In contrast, this bill permits EPA to establish standards for all harmful contaminants in the drinking water supplied by all public water systems. It also establishes a joint federal-state system for assuring compliance with these standards. The major provisions of the Act are:

1. The establishment of primary regulations for contaminants for the protection of the public health;

2. The establishment of secondary regulations for constituents in water that are related to taste, odor, and appearance;

3. The establishment of regulations to protect underground drinking-water sources by the control of subsurface injection;

4. The initiation of research on health, economic, and technological problems related to drinking-water supplies;

5. The initiation of a survey of rural water supplies; and

6. The allocation of funds to states for improving their water-supply programs.

Relationship of P.L. 93-523 to the Federal Water Pollution Control Act

In recent years there has been considerable interest in many state water-supply agencies on methods of controlling pollution of ground-water sources. In 1972, Public Law 92-500 provided mechanisms for the abatement of pollution of streams and lakes, but it offered almost no regulatory control in the protection of underground drinking water supplies.

The 1972 Water Pollution Control Act did specify that EPA should cooperate with federal, state, and local agencies and industries to develop comprehensive programs to prevent or eliminate pollution of ground water and to improve the sanitary conditions of these waters. P.L. 92-500 provides for ground-water quality monitoring programs and for EPA guidelines for the disposal of pollutants in wells and subsurface excavations.

Under the National Pollutant Discharge Elimination System provisions of P.L. 92-500, EPA is requiring NPDES permits under the following conditions:

1. When a surface discharge permit is already in effect; and
2. When there has been a surface discharge that has been replaced by a subsurface disposal system.

In April of 1974, EPA issued "Administrator's Decision Statement No. 5" as the agency policy on the protection of ground water. Under this policy, EPA opposed the emplacement of pollutants by subsurface injection without strict control and without a clear demonstration that waste injection will not interfere with the present or potential use of the ground-water resources, or otherwise damage the environment.

Under this policy, EPA can require that all proposals for injection be critically evaluated to determine that appropriate guidelines have been followed. EPA has set the policy that underground disposal should be used only as a temporary means of disposal and that it be discontinued when new treatment and waste management technology becomes available.

Decision No. 5 was drafted to protect ground water from contamination resulting from improper injection practices and from poorly sited injection wells. Guidelines have been provided for engineering and geological safeguards to protect the integrity of the subsurface environment. These guidelines are directed at preliminary investigations, design, construction, operation, monitoring, and abandonment phases of injection-well projects. Decision No. 5 also encourages development of alternative means of disposal.

Congressional Intent with Respect to Ground-Water Protection

Although some control of ground-water pollution was provided in P.L. 92-500, as noted above, Congress felt that greater protection should be afforded ground-water sources of public water supplies. This protection was provided via sections 1421, 1422, and 1423 of the National Safe Drinking Water Act that require designated states to adopt regulations to control underground injections.

In its debate, Congress indicated that potential, as well as presently-used, drinking-water sources should be protected. Congress noted that controls should be placed on any injected substance (or its derivative), whether or not that substance is a contaminant subject to a national primary drinking-water regulation. The intent of the Act is to regulate or prohibit the injection of any substance that may cause or contribute to noncompliance with primary drinking-water standards, adversely affect public health, or contribute to a ground-water source being unfit for human consumption.

Congressional hearing reports show that the definition of "underground injection" was to be broad enough to cover any contaminant that may be discharged below ground level and which flows or moves in a semi-solid, liquid, sludge, or other state.

This definition was not limited to the injection of wastes for disposal purposes, but was to cover the injection of brines and other contaminants for extraction or other purposes. The Congressional committee that held hearings on the Act did not intend that the definition apply to septic tanks or other individual residential waste-disposal systems, but that it apply to a multiple-dwelling, community, or regional system of waste injection.

The subsurface emplacement of fluids by well injection would include traditional deep-well injection of industrial or municipal wastes, but Congress did not want the nature of the fluid emplaced or the depth of injection to be the limiting elements in determining which well-injection practices were to be covered by regulations.

The term "well" was to be interpreted broadly and the scope of the regulations adopted under this part of the Act would be determined by the regulatory definition of the term. Congressional intent on this point is not clear, except to note that well injection need not be under pressure other than gravity.

Congress evinced concern over the potential reduction in the production of oil or gas because of underground injection-control regulations, and amendments to the Act were adopted to prohibit

> ". . . regulations for State underground injection control programs from prescribing requirements which would interfere with production of oil or natural gas or disposal of such biproducts associated with such production, except that such requirements are authorized to be prescribed if essential to assure that underground sources of drinking water will not be endangered by such activity.
>
> "The Committee's intent in adopting this amendment was not to require EPA to bear an impossible burden of proof as a condition of promulgation of any such regulation. Rather, the Com-

mittee sought to assure that constraints on energy production activities would be kept as limited in scope as possible while still assuring the safety of present and potential sources of drinking water."

Elements of the Act to Provide State Control

The intent of Congress as expressed in the Safe Drinking Water Act was that the various states have enforcement responsibility for ground-water protection. EPA is adhering to this mandate. For a state underground injection-control program to be approved by EPA, it must:

1. Include minimum requirements to prevent underground injections that would endanger drinking-water supplies;

2. Prohibit injection after December 17, 1978, unless by permit;

3. Allow permits for underground injection only when the applicant can prove that injection will not endanger drinking-water sources;

4. Provide for inspection, monitoring, record keeping, and reporting to EPA; and

5. Include no requirements that interfere with underground water or brine injection in oil or gas production or for secondary or tertiary oil recovery, so long as freshwater aquifers are unaffected.

State responsibility for the enforcement of underground injection regulations will be determined as follows:

1. EPA will list those states where underground injection control programs are necessary (this may be done in a staged process);

2. Each of these states must apply to EPA for approval of its program within 270 days after EPA publishes regulations on underground injection if they choose to accept program responsibility;

3. Within 90 days after a state's application, EPA may approve or disapprove the state program in whole or in part;

4. If approval is granted, the state has primary enforcement responsibility, until EPA revokes approval; and

5. If EPA reviews and revokes approval for cause, EPA has 90 days in which to rescind the disapproval or prescribe revised conditions.

EPA may find that a state has failed to enforce its underground injection-control program. The procedure in such a case is the following:

1. If EPA finds that the state program does not effectively protect ground-water quality, or if there is a violation of EPA regulations,

then EPA will notify the state;

2. If the violation lasts more than 30 days after the notification, EPA must give public notice and request the state to report within 15 days on steps being taken to comply with regulations; and

3. If the failure to comply lasts more than 60 days after notice or if the state's report is not satisfactory, EPA may bring civil action against the persons who are in violation of the regulations.

If a state does not have primary enforcement responsibility for the underground-injection regulations, EPA may bring civil action against any person thought to be in violation of a regulation. Violators are subject to fines of $5,000 per day of violation or, if such violation is willful, the penalty may be $10,000 per day.

Provisions for Protection of Sole-Source Aquifers

Section 1424(e) of the Safe Drinking Water Act states that EPA may, on its own initiative or on petition, find that an area has an aquifer which is the sole or principal drinking-water supply and that a significant hazard to public health would result. Once such a determination is made and published, no commitment for federal financial assistance (grants, contracts, loan guarantee, or other) may be made by a federal agency for any project which EPA finds may result in contamination of the area's aquifer and create a significant hazard to public health. If provided for by the law, federal financial assistance may be used in such a case to plan or design projects to assure that the area's aquifer will not be adversely affected.

Constraints on proposed projects apply only to those that are federally funded and those that will create a significant health hazard. EPA does not construe this last provision to require that a separate determination of a public health hazard be made for each proposed project in a designated region. A finding by EPA that a threat exists to the quality of the drinking water supply of a large population is sufficient to demonstrate that a significant public-health hazard could be created. The general process will be for a review of each application for federal assistance or a major project in an area where a sole-source aquifer designation has been made. Federal agencies that propose projects in such a region will be asked to prepare environmental impact statements that include the effects on the quality of water in the aquifer. The principal intent of requiring a review is to prevent the creation of a public health problem as a result of inadequate planning.

An EPA sole-source designation is not contingent on the existence or effectiveness of local and state controls to prevent pollution of the aquifer. The Safe Drinking Water Act does not provide for the inclusion of such factors in the decision of aquifer designation.

Proposed Underground Injection Control (UIC) Regulations

Prior to the issuance of the UIC regulations, EPA had sought the Safe Drinking Water Act Advisory Council's input on various facets of public policy associated with the anticipated control program. Draft regulations were submitted to working groups and to outside consultants. The oil and gas industry and state regulatory bodies reviewed the changing draft documents. It was a somewhat painful process, as recommendations were quite varied.

When finally issued, EPA felt that the UIC program regulations published in the Federal Register on August 31, 1976, would have the following effects:

1. Provide a set of regulations that met the Congressional mandate to protect both existing and potential drinking-water sources from endangerment caused by the underground injection of fluids;

2. Provide improved protection of public health by controlling certain potential sources of contamination of underground drinking water;

3. Provide minimal federal nationwide control;

4. Provide flexibility in allowing states to develop programs to meet their needs, noting that some differences in procedures from state to state will result across the nation; and

5. Provide a program whose implementation would not be excessively costly to the states nor to most injectors, although some will encumber increased costs in meeting requirements or in developing alternative methods of disposal.

After the regulations were published, three public hearings were held (Dallas, Denver, and Washington, D.C.) in September and October of 1976. EPA staff held many other information and review meetings nationwide, and comments on the proposed regulations were received until January 15, 1977. There were also presentations on anticipated problems with the proposed UIC regulations at Advisory Council meetings during this period (a significant part of the Fall, 1976, Boston meeting was dedicated to topics related to ground water). EPA awarded a contract to a consulting firm to review some specific injection practices that would be impacted. The conclusion that must be drawn is that EPA has made a determined effort to hear various points of view and to consider the broad range of concerns generated by the regulations.

Some of the principal provisions of the proposed UIC regulations are as follows:

1. Types of Well Injections Controlled--Underground injection practices that are encompassed by these regulations are: injections by municipal and industrial waste disposal wells, gas storage wells, subsidence control wells, mining wells, geothermal wells, barrier wells, recharge wells, wells for injection of brine or other fluids brought to the surface in connection with oil or natural gas production,

injection wells related to secondary or tertiary recovery of oil or natural gas, agricultural drainage wells and urban runoff wells. The regulations cover only those dug wells that can normally be recognized as wells--a dug well is one that has a depth that is greater than its largest surface dimension.

The regulations do not provide control over many practices that commonly endanger ground water: leakage from sewer mains, septic systems, highway salting, seepage from landfills, and disposal in pits, ponds, and lagoons. Surface impoundments could technically be classified as dug wells for injection purposes as many function as points of subsurface emplacement of fluids. The problem is how to define and identify pits, ponds, and lagoons that are in fact injection wells and not include all impoundments that have incidental percolation into underground strata.

2. Permitting of Existing Disposal Wells--Underground injections that were in operation under an existing state program prior to EPA approval of the state UIC program, may continue to operate for a period of up to five years under a "regulated-by-rule" provision if the operation does not endanger underground drinking-water sources. At the end of the five-year period a UIC permit must be obtained. An application must be filed for each existing underground injection that is to continue in operation and EPA will systematically review each to determine that it does not endanger an underground drinking-water source. The well operator must furnish information necessary to make such a finding. Underground injections that are found to endanger a source must be discontinued or remedial action taken. If discontinuance is ordered, the well must be plugged and abandoned.

3. Permitting of New Disposal Wells--All new disposal wells, all existing disposal wells not operated under a state program, and all existing disposal wells that have operated for five years under a state-rule process must be given a UIC permit or cease operations. Each application for a UIC permit must include a great deal of information as to location, geology, aquifers penetrated, well characteristics, information on nearby wells, injection procedures, and operating information. Contingency plans must be specified and alternative methods of waste disposal considered in the permit application. The requirements for injection wells related to oil and gas production are quite similar although details differ. No underground injection control (UIC) permit may be issued for a term greater than five years.

4. Requirements for Disposal Wells--Underground injection by industrial and municipal waste-disposal wells, subsidence control wells, barrier wells, recharge wells, mining wells, storage wells, and geothermal wells are subject to the following requirements:

(a) That all underground drinking-water sources of 3,000 mg/l total dissolved solids or less be protected by casing cemented to the surface;

(b) That the long string be cemented above the injection zone to assure that upward migration of fluid cannot occur;

(c) That injection be maintained through tubing with a suitable packer set immediately above the injection zone;

(d) That there are no leaks in the system;

(e) That surface injection pressure be limited to preclude the possibility of fracturing the formation;

(f) That completion and plugging reports for wells penetrating the aquifers of interest within a two-mile radius of the proposed well injection have been thoroughly reviewed to insure that all wells are properly completed and/or plugged so not to present a potential threat to underground drinking-water sources; and

(g) That annular injection is not practiced.

5. Requirements Applicable to All Drainage Wells--Underground injections to dispose of storm water runoff, irrigation return-flow and excess ponded-surface waters may be regulated by rule or by permit system at the option of the state.

Policy Issues Incorporated in the UIC Regulations

Some of the policy issues encompassed in the proposed UIC regulations that were commented on and discussed at various hearings are as follows:

1. Injection Practices Related to Oil and Gas Production--Part D of the proposed regulations generated a great deal of industrial and state interest, particularly from the midwest and southwestern states. The principal sources of contention here were the duplicative and extensive nature of the informational requirements of the regulations, the five-year permit renewal provisions and the failure to accept, intact, current state regulatory practices and permitting systems where adequate and effective. In addition there are a number of oil industry representatives who testified that the proposed UIC regulations will adversely impact on oil and gas production.

2. Aquifers to be Protected--The underground injection-control regulations are designed to prevent significant degradation of a potential underground drinking-water source. An underground drinking-water source is defined as an aquifer which contains water having less than 10,000 mg/l total dissolved solids. Such an aquifer need not be protected if a state can demonstrate that it is not a potential source for a public-water system because (a) the aquifer is oil-producing, (b) it is too contaminated for use as a drinking-water supply, or (c) it is in a location which makes future use of the aquifer as a drinking-water supply impracticable.

A policy issue that has been raised is the modification of this provision to protect only those aquifers where the quality is somewhat better (3,000 or 5,000 mg/l of TDS), although Congressional intent was to provide rules for aquifers with waters of up to 10,000 mg/l.

Another issue is the definition of an "aquifer," which means a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells or springs. The problem arises in the meaning of "significant" as related to a public water supply.

3. Underground Well Injection--The definition of these terms has caused some disagreement on the application of the regulations. Well injection means subsurface emplacement through a bored, drilled, driven, or dug well where a principal function of the well is the subsurface emplacement of fluids. This definition excludes surface impoundment, which may be defined as dug wells which have a depth less than the greatest surface dimension and are used for collection, storage, treatment, or disposal of fluids.

4. Endangerment of a Drinking-Water Source--The definition of endangerment could be used to prevent any subsurface injection that alters ground-water quality, which would effect a total non-degradation policy. The regulations define an underground injection that endangers a drinking-water source as being one that:

(a) May make it necessary for a public water system using an underground drinking-water source to increase treatment of the water, or

(b) Might make it necessary for a public water system which uses the source in the future to use more extensive treatment of the water than would otherwise have been necessary, or

(c) May otherwise adversely affect the health of persons, such as by adding a substance that would make water from the source unfit for human consumption.

5. Five-Year Duration of Permits and Operating Reports--There have been many questions on the value of the extensive information required for permit renewal at five-year intervals. Will this renewal process lead to the prevention of ground-water pollution? Many commenters discussed the bureaucratic and potentially wasted effort of the reports required for permit renewal. Similar complaints were raised on the requirements for weekly operating data for all injection wells, with the information to be reported quarterly. Some modifications in these two elements of the regulations appear warranted.

CONCLUSIONS

The considerable efforts that EPA has made to obtain wide review of its proposed UIC regulations can be taken as a good omen in its future enforcement of the National Safe Drinking Water Act. These open discussions of significant policy issues by a regulatory agency are refreshing. The agency's willingness to make changes will be the final test.

DISCUSSION

The discussion dealt primarily with the adequacy of EPA's approach to developing underground injection-control regulations. Mr. Hernandez provided a description of the laborious and yet inadequate process destined to lead to a set of firm regulations. He emphasized that too much attention was being focused on some activities and far too little on others.

In regard to the UIC regulations, an EPA representative stated that EPA had dealt with over 400 formal comments made in response to the regulations proposed August 31, 1976. They were currently utilizing that data in the development of a more appropriate set of regulations sensitive to the various activities which affect our nation's ground water.

IMPACT OF FEDERAL LEGISLATION OTHER THAN THE SAFE DRINKING WATER ACT ON GROUND-WATER PROTECTION

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INTRODUCTION

In reviewing the suggested federal statutes on the topic of ground-water quality protection, other statutes which impact, at least peripherally, on the subject of this paper were identified. The purpose of this review is to briefly identify the statute, to outline and summarize its general purpose, and then to identify particular sections which bear on ground-water quality protection.

It should also be emphasized at this point that the survey presented in the paper is not intended to be exhaustively comprehensive. Rather, efforts were directed toward identifying the more important statutes. These would be the ones which the average environmental engineer or other practitioner would most likely encounter in practice. I apologize for any oversights, but the scope of this project simply precluded a comprehensive review.

As a further introductory remark, it should also be emphasized that the views expressed herein are the author's and should not be interpreted necessarily as the official views of the Environmental Protection Agency. However, there was an attempt, at least for those statutes administered by EPA, to reflect the current interpretation of the statute, if that has in fact been developed within the Agency. In some cases the statutes are so relatively new that official interpretations have not been developed.

STATUTES ADMINISTERED BY THE ENVIRONMENTAL PROTECTION AGENCY

A. The Federal Water Pollution Control Act Amendments of 1972
(Public Law 92-500, 86 stat. 816, 33 U.S.C. 1151 et seq.)

The Federal Water Pollution Control Act (FWPCA) is a very complex statute. The expressed objective of the Act in Section 101(a) ". . . is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." In order to achieve the expressed goal of the Act, the Congress instituted a system wherein the technologically achievable discharge levels for various industrial and municipal waste streams were first to be ascertained. The statute then required the affected industries and municipalities to achieve these levels through the application of a permit program. This effluent-control requirement amended the earlier statute in which the primary emphasis was on achieving water-quality standards. However, the Congress did not abandon entirely the water-quality standards concept. Water-quality standards are still included in the Act, but impact direct dischargers only in those situations where the defined technology based effluent limits will not achieve 1983 goals of the Act.

Ground-water control is not extensively included within the Act. The Senate Committee on Public Works, in its report accompanying the Federal Water Pollution Control Act (Senate Rept. No. 92-414), made the following observation in its discussion of Section 402:

> "Several bills pending before the Committee provided authority to establish federally approved standards for ground waters which permeate rock, soil, and other subsurface formations. Because the jurisdictions regarding ground waters is so complex and varied from State to State, the Committee did not adopt this recommendation."
>
> The Committee went on to note that, "Ground water pollution is not as serious a national problem at present as is surface water pollution, but ground-water availability and quality is deteriorating."

However, ground-water quality is not entirely excluded from the Federal Water Pollution Control Act. Section 208 of the Act, entitled "Areawide Waste Treatment Management," requires the designation within each state of areas which, as a result of urban industrial concentrations, have substantial water-quality control problems. Within the boundaries of such designated area, each state is required to appoint a single organization capable of developing effective areawide waste-management treatment plans. The state itself would act for areas within the state which were not under a designation as a 208 area.

Paragraph (b)(2) of Section 208 requires that any plan prepared shall include a process to control the disposal of pollutants on land or in subsurface excavations within such area in order to protect ground and surface-water quality.

Furthermore, paragraph (c)(2) of Section 208 requires that the governor appoint a waste-treatment management agency which must have adequate authority to carry out appropriate portions of an areawide waste-treatment management plan developed under this section of the Act. In other words, the plan must include the processes to control ground-water quality and the agency must have the authority to enforce the plan. No Section 201 grant for construction and no NPDES permit for discharge will be made for any project not in conformance with the plan.

Section 303 of the Act entitled "Water Quality Standards and Implementation Plans," requires each state to prepare and maintain a continuing planning process. One of the requirements for approval by EPA of the state continuing planning process is that the state plan shall incorporate all elements of any applicable areawide waste-management plans under Section 208. Presumably, therefore, the state is required to enforce any ground-water provision of any 208 agency under its continuing planning process. Regulations implementing Sections 208 and 303 are contained in 40 Code of Federal Regulations (CFR), Parts 130 and 131.

Section 304 of the Act, entitled "Information and Guidelines," requires the agency to issue information which shall include guidelines for identifying and evaluating the nature and extent of non-point sources of pollutants; and processes, procedures, and methods to control pollution resulting from, among other things, the disposal of pollutants in wells or in subsurface excavations. The initial report has been published[1] and has been serialized in Water Well Journal, published by the National Water Well Association.

Section 402 of the Act, entitled "National Pollutant Discharge Elimination System," authorizes the issuance of permits for the discharge of pollutants to the navigable waters. This section permits the Administrator to delegate the entire permit program to states desiring to administer their own programs and having adequate authority to issue permits which, among other things, control the disposal of pollutants into wells (Section 402(b)(1)(d)). For those states not qualifying for or not requesting the delegation, the permit program can be operated as a federal permit program. Because of an apparent quirk in the Act, the Agency has determined that when the system is operated as a federal permit system, the Administrator cannot control the disposal of pollutants into wells unless the same discharger has both a direct discharge to navigable waters and a disposal into a well. Therefore, in any state in which the permit program is a responsibility of EPA, any discharger who discharges all of his pollutants into a well is not subject to any NPDES permit.

These four sections outline the Act's basic content regarding ground-water quality protection.

B. Toxic Substances Control Act
(Public Law 94-469, 90 stat. 2003, 15 U.S.C. 2601 et seq.)

The Toxic Substances Control Act (TSCA) was enacted on October 11, 1976, with an effective date of January 1, 1977. The Congress defined as national policy in the Act that adequate data should be developed with respect to the effects of chemical substances on health and the environment, and that the development of such data should be the responsibility of those who manufacture and process such chemical substances. The TSCA requires the Agency to establish protocols for testing chemical substances and mixtures, requires that manufacturing and processing notices be provided to the Agency by manufacturers of the manufacturing and processing of toxic substances, and requires regulation of hazardous chemical substances.

Section 6 of TSCA provides for the regulation of hazardous chemical substances. This section provides seven individual requirements that can be applied either individually or in a combination by the Administrator when he finds that the manufacture, processing, or distribution in commerce, use, or disposal of a chemical substance presents an unreasonable risk of injury to health or the environment. Among the authorities provided is that the Administrator may establish a requirement prohibiting or otherwise regulating any manner or method of disposal of such substance or mixture by its manufacturer or by any person who uses or disposes of such a substance for a commercial purpose. Presumably this would include disposal in or on the land.

Subsection (e) of Section 6 regulates the manufacture and distribution of PCB's. As an example, in prescribing the methods for disposal of PCB's, the Agency is considering under what conditions and for how long a period of time disposal into various types of landfills would be permitted. The interface of the PCB disposal requirements under TSCA with any forthcoming regulations under the Resource Conservation and Recovery Act have not as yet been resolved by the Agency.

C. Resource Conservation and Recovery Act of 1976
(Public Law 94-580, 90 stat. 2795, 42 U.S.C. 6901 et seq.)

In the congressional findings introducing the Resource Conservation and Recovery Act of 1976 (RCRA), the Congress found that open dumping is harmful to health, contaminates drinking water from underground and surface supplies, and pollutes the air and the land (Section 1002(b)(4)). As an objective, Congress intends the Act to promote the protection of health and the environment by regulating the treatment, storage, transportation, and disposal of hazardous wastes which have adverse effects on health and the environment (Section 1003 (4)). Hazardous waste management is controlled under subtitle (C) of the Act which encompasses Sections 3001 to 3011.

Section 3001 requires that the Administrator, within 18 months after passage of the Act, shall promulgate regulations identifying the characteristics of hazardous wastes and listing particular hazardous waste which shall be subject to the provisions of the Act. Section 3002 then requires that so-called generators of hazardous waste who are identified and listed by provisions of the Act shall be subject to standards established by the Administrator. These standards will require, among other things, record-keeping, labeling, specification of appropriate containers; furnishing of information of chemical composition to persons transporting, treating, storing, or disposing of such waste; the use of a manifest system to assure that all hazardous waste generated is designated for treatment, storage, or disposal; and for the submission of reports to either the Administrator or appropriate state agency. Section 3003 establishes standards which are applicable to transporters of hazardous waste; Section 3004 establishes standards applicable to owners and operators of hazardous waste treatment, storage, and disposal facilities; Section 3005 establishes permits for treatment, storage, or disposal of hazardous waste. In order to qualify for a permit, each applicant must supply information which, among other things, requires estimates with respect to the composition, quantities, and concentrations of any hazardous substances which are proposed to be disposed of at the site, and a description of the site itself in which the hazardous waste is to be disposed of, treated, transported, or stored. Section 3006 provides that, pursuant to federal guidelines, the Administrator may authorize state hazardous-waste programs in lieu of the federal program. Section 3007 provides that, for purposes of developing or assisting in the development of any regulations or enforcing provisions, any person who generates, stores, treats, transports, disposes of, or otherwise handles hazardous waste shall provide to any officer or employee of the EPA or of a state having an approved program access to records or collection of samples at any reasonable time upon a proper request. Such information would be available to the public except as protected as confidential information in accordance with Section 1905 of Title 18 of the United States Code. The Administrator is authorized to issue compliance orders and to assess both civil and criminal penalties with fines up to $25,000 per day for each day of continued noncompliance and, in the case of criminal penalties, for imprisonment not to exceed one year and a $25,000 fine.

Section 8001 of the Act, entitled "Research, Demonstrations, Training, and Other Activities," provides in paragraph 10 for studies, investigations, experiments, etc. of improvements in land-disposal practices for solid waste which may reduce the adverse environmental effects of such disposal and other aspects of solid waste disposal on land.

D. Federal Insecticide, Fungicide, and Rodenticide Act as Amended by the Federal Environmental Pesticide Control Act of 1972

(Public Law 92-516, 86 stat. 973, 7 U.S.C. 136 et seq.)

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is the principal Act by which the EPA controls the labeling of pesticides. The Act is principally concerned with the procedures for registering pesticidal products. No pesticidal product may be distributed in commerce without an appropriate label and registration under FIFRA.

Section 19 of FIFRA provides for the disposal and transportation of pesticides. This section requires the Administrator to establish procedures and regulations for the disposal or storage of packages and containers of pesticides and for the disposal or storage of excess amounts of such pesticides and to accept at convenient locations for safe disposal a pesticide for which the registration has been cancelled under Section 6 of the Act. EPA has promulgated regulations for such pesticide disposal and these are contained in 40 CFR Part 165. The regulations provide in certain circumstances for deep well injection (40 CFR 165.8(a)(6)) and for disposal of pesticide containers by burial (40 CFR 165.9).

E. Summary

The four statutes discussed above constitute the principal authorities relating to ground water administered by the EPA. However, the EPA does participate in other programs which may impact ground-water quality. For example, the Ohio River Basin Water Sanitation Commission (ORSANCO) is an interstate compact which has been approved under the Federal Water Pollution Control Act. The Agency is a member of ORSANCO. ORSANCO has issued a guidance document on deep-well injection of wastes. The Agency also participates in activities under the Water Resources Council, which may at times consider ground-water related projects. Since the Agency is not directly responsible for administering such programs, they will not be addressed herein.

STATUTES PRINCIPALLY ADMINISTERED BY OTHER FEDERAL AGENCIES

A. Atomic Energy Act of 1954
(42 U.S.C. 2011 et seq.)

The Atomic Energy Act is now principally administered in its regulatory functions by the Nuclear Regulatory Commission. The Act itself has two sections which provide a basis for the control of radioactive emissions to the environment. In 42 U.S.C. 2021(c)(4), the statute requires that the Commission shall retain authority and responsibility with respect to the regulation of the disposal of such other byproduct, source, or special nuclear material as the Commission determines by regulation or order should, because of the hazards or potential hazards thereof, not be so disposed of without a license from the Commission. In Section 42 U.S.C. 2201(p), the Commission is ". . . authorized in the performance of its functions to make, promulgate, issue, rescind, and amend such rules and regulations as may be necessary to carry out the purpose of this chapter."

Under Reorganization Plan Number 3 of 1970, by which the Environmental Protection Agency was formed, Section 2(a)(6) assigned to the EPA the functions of the Atomic Energy Commission, under the Atomic Energy Act of 1954, which were administered through its Division of Radiation Protection Standards to the extent that such functions consisted of establishing generally applicable environmental standards for the protection of the general environment from radioactive material. The reorganization plan defined the term "standards" to mean limits on radiation exposure or levels, or concentrations, or quantities of radioactive material in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material. In attempting to further delineate the authorities between the two agencies, two so-called "memorandums of understanding" have been agreed upon between the two agencies. The first was entitled AEC-EPA Memorandum of Understanding with Respect to AEC-Licensed Facilities and was signed on August 19, 1973. The second was similarly titled and was issued during November, 1973. The EPA has refused to issue NPDES permits for discharges to the navigable waters of source, byproduct, and special nuclear materials from NRC and NRC-licensed facilities. This refusal was recently upheld by the U.S. Supreme Court in the case of Train v. Colorado Public Interests Research Group, Inc., 96 S. Ct. 1938, (June 1, 1976). Furthermore, state regulation of these same materials was denied in the case, Northern States Power Company v. The State of Minnesota, 447 F. 2d 1143 (1971), affirmed summarily 405 U.S. 1035, 92 S. Ct. 1307 (1972). As a result of these court holdings, EPA issued regulations (40 CFR Part 190) entitled Environmental Radiation Protection Standards for Nuclear Power Operations. These standards were promulgated on January 13, 1977 (42 F.R. 2858). They are intended to apply to radiation doses received by members of the public in the general environment and to regulate the materials introduced into the general environment as a result of operations which are part of a nuclear fuel cycle.

All NRC regulations are contained in the Code of Federal Regulations, Vol. 10. Through its reserved powers, the NRC clearly has the authority to regulate the discharge of source, byproduct, and special nuclear material, released from its own facilities or from licensed facilities which may be discharged beneath or into the land atmosphere (see 10 CFR Section 20.301 to Section 20.305).

B. National Environmental Policy Act of 1969

(Public Law 91-190, 83 Stat. 852, 42 U.S.C. 4321 et seq.)

Most people actively engaged in some aspect of environmental protection are aware, in at least general terms, of the requirements contained in the National Environmental Policy Act of 1969 (NEPA). Because of the judicial interpretation afforded this statute during the large amount of litigation that has ensued under its auspices, many federally sponsored construction projects as well as other actions of federal agencies have been significantly affected. Although NEPA is a relatively brief statute, the congressional goals outlined in it are quite broad.

Section 2 of NEPA expresses the congressional declaration of purpose in enacting the statute. Congress included language such as ". . . to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation. . . ."

The real teeth of NEPA are contained in Section 102, "Cooperation of Agencies; Reports; Availability of Information; Recommendation; International and National Coordination of Efforts." It begins:

> "The Congress authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policy set forth in this chapter, and (2) all agencies of the federal government shall . . . (c) include in every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment, a detailed statement by a responsible official on (i) the environmental impact of the proposed action, (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented, (iii) alternatives to the proposed action, (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented [emphases added]."

This section prescribes the requirements for the environmental impact statements which are so well known.

Even though NEPA does not affect ground-water quality directly, the Act does require that, when applicable, ground-water quality, among other environmental concerns, should be considered in any environmental impact statement that would be prepared. These impacts would then be subject to review by appropriate agencies and must be considered before the final project design. It should be noted that NEPA does not require an agency to forego or drastically change a project solely because of its environmental impact. All the statute requires is that these impacts be delineated and that they be considered before the final agency action. In this regard, then, NEPA cannot be considered as a substantive statutory requirement incorporating environmental quality into projects, but rather a directive to study such impacts.

C. Control of Ground Water Quality Protection on Federal Lands and Federal Facilities

The underground environment is protected on federal lands during the investigative explorative operations, and abandonment phases of various oil and mineral operations under various statutes administered within the Department of the Interior (principally within the U.S. Geological Survey). The author has not attempted to itemize all of the various statutory authority-casting, since frequently the titles of the statutes are not particularly enlightening. For example, the statute may be entitled, "The Alaska Coal Leasing Act of October 20, 1914" or "The Outer Continental Shelf Lands Act." Much of the environmental protection is under general authorities contained in those statutes and is best understood by reviewing the various interpretive regulations issued by the Geological Survey. For example, the Geological Survey regulations frequently include language in one form or another which requires a lessee to ". . . take such action as may be needed to minimize, control, or prevent . . . (3) pollution of surface or ground waters. . . " (Coal Mining Operating Regulations, 30 CFR 211.4). Other regulations with much the same content include the Operating Regulations for Exploration, Development, and Production (30 CFR 231.4); Prohibition Against Causing Pollution in Geological and Geophysical Explorations of the Outer Continental Shelf (30 CFR 250.43); and To Protect the Environment, Including Ground Water Quality for Geothermal Resource Operations on Public Acquired and Withdrawn Lands (30 CFR 270.15). While statutory authority does exist on federal lands to protect ground-water quality from mineral and oil exploration and operations, no statutory authority directly affecting such activities was found other than those laws administered by EPA (e.g., Section 208 of the FWPCA). Perhaps legislation under consideration by the Congress for controlling coal mining and subsequent reclamation may provide additional authority in this area on non-federal lands.

D. Executive Orders (E.O. 11514 and E.O. 11752)

Executive Order 11514 was issued by the President on March 5, 1970 (35 F.R. 4247). The purpose of this Executive Order was to provide guidance to federal agencies for the implementation of the National Environmental Policy Act of 1969. In terms of policy, it required federal agencies to initiate measures needed to direct their policies, plans, and programs so as to meet national environmental goals. The Executive Order required federal agencies to do the following: (a) monitor, evaluate, and control on a continuing basis their activities as to protect and enhance the quality of the environment; to develop procedures to ensure the fullest practicable provision of timely public information and understanding of federal plans and programs with environmental impact in order to obtain the views of interested parties, including and providing for public hearings and alternative courses of actions;

ensure that information regarding existing or potential environmental problems and control methods developed as part of research, development, demonstration, test, or evaluation activities be made available to federal agencies, states, counties, municipalities, institutions, and other entities, as appropriate; review their agency statutory authority, administrative regulations, policies, and procedures, including those relating to loans, grants, contracts,leases, licenses, or permits, in order to identify any deficiencies or inconsistencies therein which prohibit or limit full compliance with the purposes and provisions of the Act; engage in the exchange of data and research results, and cooperate with agencies of other governments to foster the purposes of the Act; and to proceed, in coordination with other agencies, with actions required by Section 102 of NEPA.

Executive Order 11752, entitled Prevention, Control, and Abatement of Environmental Pollution at Federal Facilities, was issued on December 17, 1973 (38 F.R. 34793). The Order states as a policy the following:

> "It is the purpose of this Order to assure that the federal government, in the design, construction, management, operation, and maintenance of its facilities, shall provide leadership in the nationwide effort to protect and enhance the quality of our air, water, and land resources, through compliance with applicable standards for the prevention, control, and abatement of environmental pollution in full cooperation with state and local governments. Compliance by federal facilities with federal, state, interstate, and local substantive standards and substantive limitations, to the same extent that any person is subject to such standards and limitations, will accomplish the objective of providing federal leadership in cooperation in the prevention of environmental pollution."

Section 3 of the Order outlines the responsibilities of the heads of federal agencies with regard to facilities under their jurisdiction. The agencies are required to cooperate with the Administrator of EPA and state, interstate, and local agencies in the prevention, control and abatement of environmental pollution; to present on an annual basis to the Director of the Office of Management and Budget a plan to provide for the improvement in the design, construction, management, operation, and maintenance of existing facilities as may be necessary to meet applicable standards; include in budget requests for the design and construction of new facilities such measures as may be necessary to meet applicable environmental standards; and to require that lessees assume full responsibility for complying with standards for the prevention, control, and abatement of environmental pollution.

The Administrator of EPA is required to provide technical advice and assistance; review federal facility compliance with standards; provide liaison to ensure that action is taken by federal agencies or coordinated with state and local programs; mediate conflicts between federal agencies, state, and local groups, develop a coordination strategy for federal facility compliance with applicable standards; and, finally, to maintain a continuing review of the implementation of the Order. The Order then goes on to require that federal facilities be designed, constructed, managed, operated, and maintained so as to conform with the Clean Air Act, Federal Water Pollution Control Act, Marine Protection, Research, and Sanctuaries Act of 1972, Solid Waste Disposal Act, Federal Noise Control Act of 1972, appropriate portions of the Atomic Energy Act, and the Federal Insecticide, Fungicide, and Rodenticide Act. It is not known whether this particular Executive Order may be amended to encompass newer legislation such as the Safe Drinking Water Act or the Toxic Substances Control Act.

SUMMARY

This paper has presented a quick and necessarily superficial overview of much federal legislation impacting environmental control with a focus on ground-water quality protection, where that is specifically identified within the Acts. There undoubtedly are other statutes which have some bearing on ground-water quality protection--for example, court interpretations of statutes protecting Indian water rights. However, it would appear that, for most situations in which federal action is involved, some consideration of ground-water quality is authorized. Whether or not that consideration is sufficient depends on one's perspective.

FOOTNOTES

1. Environmental Protection Agency, Ground-Water Pollution From Subsurface Excavations." EPA-430/9-73-012, U.S. Gov. Printing Office, Washington, D.C. (1973).

DISCUSSION

Discussion centered around a desire for more explicit explanation of the four primary federal laws capable of controlling ground-water pollution, namely:

1. 92-500 - Water Pollution Control Act
2. 93-523 - Safe Drinking Water Act
3. 94-469 - Toxic Substances Control Act
4. 94-580 - Resource Conservation and Recovery Act

Mr. Ballentine pointed out the nuances of each piece of legislation and the breadth of coverage that could be attained with each law. Several conferees indicated that strict coordination among the offices of EPA managing these different laws would be required in order to develop a feasible ground-water pollution control policy.

It was stated by an EPA representative that a concerned effort was being made to integrate ground-water pollution-control policies established within EPA over the four aforementioned pieces of legislation and that close communication would be achieved.

THE STATE APPROACH TO GROUND-WATER PROTECTION: THE PENNSYLVANIA EXPERIENCE

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I had originally intended to begin my presentation by telling you about the 1971 pipeline break in Montgomery County, Pennsylvania, which leaked 130,000 gallons of Sunoco 260 gasoline to the ground water. It took four years, 43 wells, and more than $2 million to restore ground-water quality and return two municipal supply wells into service. But I decided a more recent event would be of more interest today. This recent incident also took place in Montgomery County. A fuel oil deliveryman hooked up to an outside fill pipe for a private residence and proceeded to fill the basement storage tank. He pumped 1,100 gallons, although most basement tanks hold only about 250 gallons. This was only part of his error, however, for it seems that five years ago the homeowner removed his basement tank and had put in an outdoor buried tank. To further compound the problem, the owner's sump pump pumped the oil into his septic tank and tile field, and he now has oil everywhere.

Although these incidents represent relatively new types of water-pollution problems, the need for clean water is not new. Over the last century, many diseases and maladies have been associated with unclean water. Historically, the emphasis has been to protect surface water, with little thought given to ground water. Because ground water is not readily visible, it is often ignored until a problem develops. In fact, discharges to ground water--such as leaky industrial waste treatment and storage impoundments, land application of wastes and waste waters, and direct discharges to ground water--have been considered by some to be ideal disposal techniques because they are not direct discharges to surface waters. They are thought not to affect surface-water quality. Many of those directly concerned with our nation's water quality either do not understand or forget about the role of ground water in the hydrologic cycle and its impact on surface water. Effective water-pollution abatement programs cannot deal with surface water while ignoring ground water.

With the exception of water released from surface storage reservoirs, the source of all water in surface streams is either direct runoff from precipitation and channel precipitation or ground-water discharge. For example, consider where the water comes from that flows in a stream during August or September when it may not have rained for the past month. During the growing season and the dry times of the year, the streamflow may be as much as 100 percent ground-water discharge. From these facts, it is obvious that the quality of surface water can only be as good as the quality of ground water.

But the protection of ground water is considerably more complicated than protection of surface waters. Ground water may be polluted by any liquid or soluble pollutant that is placed in the subsurface or on the land; whether by land disposal facilities, spills, or intentional direct discharges. Surface water is polluted by point sources (pipes) and non-point source discharges, including polluted ground water. A direct discharge of a polluting substance to surface waters need only be stopped, and in a matter of weeks or months the water will usually revert to an unpolluted condition. On the other hand, water within the ground moves very slowly and the flow may be measured in terms of only feet per day to feet per year. Thus, once ground water is polluted, it may take tens to hundreds of years to restore it to its original quality.

Even in a water-rich state like Pennsylvania, ground-water protection is essential. It is estimated that there are 47 trillion gallons of ground water in "storage" in Pennsylvania. The annual average precipitation in the state is 32 trillion gallons. Precipitation and ground-water discharges produce 21 trillion gallons of streamflow. The total streamflow for an average year is estimated to consist of 60 to 70 percent ground-water discharge. Total ground-water production for all uses is on the increase in Pennsylvania.

PENNSYLVANIA CLEAN STREAMS LAW

The Clean Streams Law of Pennsylvania is the basis for rules and regulations to protect both surface and ground waters. Some definitions from the law are worth quoting here.

> "Waters of the Commonwealth shall be construed to include any and all rivers, streams, creeks, rivulets, impoundments, ditches, water courses, storm sewers, lakes, dammed water, ponds, springs and all other bodies or channels of conveyance of surface and underground water or parts thereof whether natural or artificial within or on the boundaries of this Commonwealth.
>
> "Industrial waste shall be construed to mean any liquid, gaseous, radioactive, solid or other substance, not sewage, resulting from any manufacturing or industry or from any establishment as herein defined and mine drainage, silt, coal mine solids, rock, debris, dirt and clay from coal mines, coal collieries, breakers or other coal processing operations. Industrial waste shall include all such substances whether or not generally characterized as waste."

The Law further stipulates that discharges of sewage, industrial wastes, or any substances to the waters of the Commonwealth which causes or contributes to pollution or creates a danger of pollution is declared not to be a reasonable or natural use of such waters. No person or municipality shall discharge or permit the discharge of industrial wastes or sewage in any manner directly or indirectly into the waters of the Commonwealth without a permit unless such discharge is authorized by the rules and regulations. The Pennsylvania Clean Streams Law allows the Department of Environmental Resources to implement a ground-water quality protection program through the development of regulations.

GROUND-WATER PROTECTION IN PENNSYLVANIA

This program which began in 1963 as a part of the state's water pollution control program has grown considerably as the problems and needs were presented and understood. Wastewater treatment project reviews include consideration of the ground-water element. Rules and regulations have been developed to control serious problems related to wastewater impoundments, sanitary landfills, petroleum storage, mining, and land disposal of waste waters.

The national environmental protection movement and increased funding of environmental programs were the catalysts for our increased ground-water protection program in the early 1970's. Today 23 hydrogeologists work in three different bureaus under the Office of Environmental Protection.

The Ground-Water Section in the Bureau of Water Quality Management, Division of Water Quality, is staffed by 13 hydrogeologists, 3 stationed at the central office in Harrisburg and 10 divided among 7 regional offices. The charge and function of the Ground-Water Section is the abatement and prevention of ground-water pollution. The Bureau's Division of Industrial Waste has one hydrogeologist in the central office who reviews applications for deep mine drainage permits and mine sealing proposals.

The Bureau of Land Protection, Division of Solid Waste Management, has two hydrogeologists in the central office at Harrisburg who provide solid waste disposal technical direction to the 10 regional geologists in the Bureau of Water Quality Management. They also develop the ground water and geologic aspects of procedures, guidelines and rules and regulations relative to solid waste managment.

The Bureau of Surface Mine Reclamation, Division of Surface Mine Control and Reclamation, has seven hydrogeologists in Harrisburg who work to protect the waters of the Commonwealth from pollution associated with surface mining and to insure the proper restoration and conservation of land. This is accomplished through review of applications for surface mining permits, research of new mining methods for operational efficiency and environmental protection, and the development of rules, regulations, and guidelines.

Because comprehensive ground-water protection hydrogeology is not taught in universities, we have had to develop in-house training. Through supervised work experience, literature reviews, problem discussion meetings, and special training sessions, we train new employees and provide a continued updating for existing staff.

The ground-water protection program in Pennsylvania encompasses two main areas of activity: (a) ground-water pollution abatement, and (b) ground-water pollution prevention.

Ground-Water Pollution Abatement

To accomplish the abatement portion of the program, personnel from the affected programs cooperate in investigations of existing ground-water pollution, identify the source of the pollutant and the responsible party and, if necessary, function as expert witnesses in resulting legal proceedings. Our goal is to require the responsible party to make a concerted effort and to use all practical means to restore ground water to its unpolluted condition. This effort usually will require the responsible party to hire a competent hydrogeologist and to use the latest ground-water pollution abatement technology. We review abatement proposals and monitor the activities of these professionals to insure the success of the abatement program. We find that by requiring the responsible party to develop the clean-up procedure, we accomplish much more ground-water restoration than would be possible if we did this work ourselves.

Ground-Water Pollution Prevention

The prevention part of our program can be divided into two areas: (1) the review and investigation of proposals for land disposal of solid and liquid waste and applications for mining and mine drainage permits; and (2) the development of guidelines, rules and regulations, and standards to prevent future ground-water pollution and maintain existing ground-water quality to the highest degree practicable. In the review and investigation area, we have rules and regulations which require the applicant to supply detailed soils, geology, and ground-water data. Normally, this requires the applicant to secure the services of experts in these fields. We then review the application with office and field investigations of the site to determine if the site and the proposed techniques will, in fact, protect ground water.

In the second part of our prevention program, rules and regulations and guidelines have been developed for sanitary landfills, waste storage and treatment impoundments, spray irrigation of waste waters, and surface mining and mine drainage. We are presently developing regulations for the installation and maintenance of hazardous liquid storage tanks, such as service station gasoline storage and hazardous liquid storage tank farms, and sludge disposal.

We are also developing ground-water quality criteria and standards. We believe that the development of realistic and meaningful standards for the humid, temperate climate of Pennsylvania will constitute a first in ground-water quality protection. It is my opinion that the development of numerical standards for ground-water quality on a basin-by-basin basis is not possible with limited existing data. The cost of developing detailed ground-water quality data would run to the millions of dollars. We therefore are presently working with existing data in an attempt to develop standards based on ground-water uses. This approach will consider the various ground-water uses such as domestic water supply, public water supply, industrial water supply, surface water low-flow maintenance, and wastewater dispersion and dilution.

We are involved in the Pennsylvania Comprehensive Water Quality Management Planning program (COWAMP), one of the first statewide water resource studies to include ground-water protection as a major study element. Its specific goal is to protect or to improve the quality of Pennsylvania's waters. Including ground water as a major study element greatly benefits the ongoing active ground-water protection program. A data base using existing data has been developed from various state agencies, the U.S. Geologic Survey, university records, chemical laboratories, and from citizens who have reliable information on their wells. These data are being computerized and will be available to anyone interested in ground-water quality information. Critical areas requiring additional study are being identified and water quality and quantity problems will be brought to the attention of the state environmental protection agencies. The existing ground-water quality monitoring program is being evaluated, and methods of improving it into a more meaningful system are being investigated. Data gaps are being identified and it is hoped that programs will be developed to fill them. Each of these outputs mentioned above would have required a separate study by Department staff if COWAMP had not been undertaken.

Activities Indirectly Related to Pollution Prevention

In addition to the above functions and activities, the ground-water staff performs hydrogeologic reviews and provides technical advice to other state programs which have an effect on ground-water quality. We act as hydrogeologic advisors to legal staff researching existing ground-water law with the goal of writing new laws relative to ground-water conditions as they exist in Pennsylvania. We have recently formed a "Ground-Water Quality Group," composed of geologists, soil scientists, and related personnel representing environmental protection programs regulating surface mines, mine drainage, solid-waste management, on-lot septic systems, and domestic and municipal ground-water supplies. The prime purpose of the group is to achieve coordination in the total ground-water protection program under the Office of Environmental Protection.

GROUND-WATER QUANTITY

The Pennsylvania ground-water protection program, as pointed out, is active in ground-water quality protection. At present we have no legal remedy for regulating ground-water use. Excessive ground-water withdrawal, especially dewatering activities and high-production wells, can result in ground-water mining and interferences and can have a deleterious effect on quality. Although Pennsylvania is ground-water rich, we are presently experiencing serious ground-water mining in some of the highly urbanized areas. Dewatering in conjunction with mining is apparently causing serious quantity and quality problems in at least one basin. I sincerely believe that quantity controls and quality protection are closely related and one cannot be addressed without affecting the other.

CONCLUSION

In closing, I wish to emphasize that a strong ground-water protection program must be based on strong laws and on a qualified, well-trained staff, in adequate numbers to effectively carry out the program. We have found the pollution-abatement portion of our program demands considerable staff time. The requirement for polluters to use competent ground-water consultants to develop abatement procedures has reduced this demand on our staff time.

I wish also to emphasize that ground-water protection must be an integral part of all water-quality management programs. Meaningful ground-water protection must consider ground-water quantity use as well as quality protection.

THE STATE APPROACH TO GROUND-WATER QUALITY PROTECTION: THE ILLINOIS EXPERIENCE

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Like many states, Illinois depends both on surface water and ground water to fulfill the state's vital need for drinking water, irrigation, and industrial use. Approximately one-third of the state's inhabitants depend upon drinking water from underground resources; fortunately, these resources have been relatively free from society's pollutional activities. However, the ever-increasing need for utilization of ground water and the growing concern over the threat of polluting our ground-water resources has focused on the need for programmatic protection and conservation of this resource.

The division of state government which I manage--the Division of Land Pollution Control--is responsible for the safe, economical, and environmental disposal of domestic wastes, liquid wastes, and hazardous wastes. We currently have permitting authority in each of these areas as well as permitting authority for underground injection wells. Since the improper handling of these activities can obviously bring about the pollution of ground water, we have been charged within the framework of the Illinois Environmental Protection Agency with the responsibility of ground-water protection and the ultimate development of a state ground-water policy. We are, of course, not the single state agency concerned with matters of ground water. In addition to our agency's regulatory authority, the Illinois Department of Public Health and the Illinois Department of Mines and Minerals also have a regulatory interest in ground-water protection. Research and resource interest and responsibility is shared by the Illinois State Geological Survey, the Illinois State Water Survey, and others. You can see that, just as in surface-water matters, ground water also has a cast of thousands.

We who have been concerned with clean air, clean water, and unpolluted land face a paradox. In discussing the interaction of environmental disciplines, Barry Commoner is said to have stated that "there is no free lunch," a statement that certainly comes home to roost. The exotic materials that we have cleaned from our air and the products of wastewater treatment must not be returned to the air or to the water. As much as we would like to keep this burden from the land, we have not reached the sophistication to accomplish this goal or even reduce the burden by much. Therefore, the land is the last viable source of disposing of the day-to-day domestic refuse and huge volumes of industrial residue that our society creates daily. Even when the day of high technology recycling comes, there will be a residue left that must go to the land. It goes without saying, then, that land disposal must be managed in a thorough and environmental fashion. We have been striving to do this in Illinois since 1970, when the Illinois Environmental Protection Act gave us new authority and revitalized environmental initiatives of the past. Illinois is fortunate in having all of the component parts necessary to complete management of environmental residue. By that, I mean we have the ability to plan, to regulate, and to enforce. We have permitting authority and research capability. Additionally, we are lucky enough to have great quantities of impermeable clay.

Historically, before the advent of the Illinois Pollution Control Act of 1970, the state had the authority to register, but not permit, disposal sites. This program had very little in terms of enforcement capability, and most of the state's activity was directed toward advising or perhaps even bluffing to try to upgrade more than 1,500 refuse sites located throughout the state. Very few of these sites could be considered landfills, and I would be hesitant to add the prefix "sanitary" to the operations at that time. Not only were there problems with surface and subsurface waters being polluted, but it was easy to seek out one of these locations; all one had to do was follow the plume of smoke. After 1970, the state began developing, under its new powers, solid-waste rules and regulations. By 1974, Illinois, by participating in Operation 5,000, a federal program to eliminate that many open dumps throughout the United States, and on its own initiative, had closed nearly 800 of these open-burning garbage dumps. Continuing in our efforts up to this point, I can happily say that Illinois is one of the few states that no longer has open-burning garbage dumps. We have reduced the number of sites to approximately 400 sanitary landfill sites throughout the state. These sites are handling more than 8 million tons of domestic refuse per year.

Permitting of these landfill sites has become a complex procedure for both the state and the applicant. Up until approximately a year and a half ago, the Agency examined and issued Developmental Permits on the basis of the engineering and hydrogeologic attributes of the site. A complete subsurface examination was necessary, and the engineering requirements generally included a number of sample wells to be installed as condition of the permit. After the Agency had satisfied itself through on-site inspection that all of the developmental work had been completed according to specification, then an Operational Permit was issued. Routine field inspection and sampling then follows. However, the Illinois Supreme Court, in the Carlson v. The City of Worth decision, placed the Environmental Protection Agency in the position of being the sole siting authority for landfills in the state. We had previously made local zoning a condition of permit. But with our new authority, that no longer could be done legally by the Agency.

Developmental Permits to site new landfills in Illinois are now examined by our Agency in terms of many traditional planning and zoning considerations--such as historical and archeological value, transportation and noise impact, local property value--as well as our thorough engineering and hydrogeologic evaluation.

Illinois allows liquid and special waste to be incorporated into solid-waste landfills in a few selected sites. This has been looked on as a controversial and perhaps unwise decision on Illinois' part by others--including some of our sister states, whose ecological health depends on Illinois taking some of their noxious waste from time to time. Prior to 1972, we did not allow such liquid or special waste to go into our landfill sites. But after that date, even though the Agency was still somewhat reluctant, we relented and allowed a few disposal sites that we were confident of to accept some liquids and sludges. A special supplemental permit, for that particular volume of waste only, was issued on a one-to-one basis. That process still exists. We began in 1972 in issuing permits to dispose of around 1,500 tons of such waste each month. By 1974, we began to realize that it was impossible to ignore the great volume of liquid and special waste which were being generated in the state. Obviously, these wastes were going somewhere, whether it be nearby streams or sewers, or dumped on farmland or in a sand pit behind a manufacturing plant. Our philosophy was that it was better that these materials be identified and placed in secure landfills where we knew the permeability of soils than that they be irresponsibly dumped almost directly into the surface and ground waters of the state. By 1974, we had issued, under supplemental permit, permission for approximately 100,000 tons of industrial waste per month to go into these 20 or so landfills. This upward trend has continued, and during the calendar year 1976 the Division issued over 800 supplemental permits to these few sites to accept more than 200,000 tons of industrial residue each month. This is equivalent to a liquid volume in excess of 48 million gallons per month. To the best of our judgment, this involves less than 35 percent of these similar materials being generated in Illinois.

Before I go further, I should answer some of the questions which I imagine have already occurred to you. One of these, I am sure, is "What are these wastes, who produces them, and where were they going before landfills became a legal alternative?" Our experience is beginning to provide these answers, yet we still have a long way to go. As I have been speaking of industrial residue or special wastes or even the much-abused term "hazardous waste," I am referring to materials which generally are process effluents and which evolve from direct or indirect creation of a product or service. Although many are unique to their source, a partial list of these by-products would include spent pickling liquors, cutting oils, chemical catalysts, distillation bottoms, etching acids, equipment wash waters, spray-booth paint sludges, metal dust sweepings, chemical spill cleanings, and hospital waste. As was pointed out earlier, there also is an ever-increasing volume of exotic materials that are being cleaned from our air and surface waters through other pollution-control initiatives. The volume of lagooned waste in Illinois is not known at this time, but an effort will begin to inventory such sources. Two years ago, the Agency was successful in amending the state legislation to allow us to control through permits the deposition of hazardous waste generated and disposed of on the same property. Agency resource constraints have not allowed us to move ahead in this area as quickly as we choose. We hope that additional dollars will be available through the Federal Resource Conservation and Recovery Act, and that this will allow us to begin to address this problem area in a thoroughgoing fashion.

The Agency has recently developed new criteria for the land disposal of special waste. These new criteria have been developed not only for the policy of protecting our ground-water resources, but with the recognition that pre-treatment of waste must be accomplished to the highest degree practicable; that recover, recycling, and reuse must be encouraged to the greatest degree, and that a realistic source of disposal be made available for these materials. Failure to provide legal and environmentally sound disposal alternatives is, in the Agency's view, tantamount to promoting the opposite effect. To allow for the disposal of these materials and to assume the responsibility for the materials that are generated in our state, we have a number of land-disposal methods which are being used. These methods are as follows:

(a) Direct sanitary landfilling--This is the easiest and most common method of disposal and, in most cases, involves little more than incorporating the waste into the fill. Generally we do not permit volumes to exceed 10 gallons per compact of cubic yard of dry refuse in trench type disposal sites, and we do not permit highly alkaline or highly volatile materials or those which display high degrees of dermal or inhalation toxicity to be disposed of in this manner.

(b) Subsurface injection--Illinois currently has eight such wells disposing of highly alkaline, highly volatile, or highly toxic materials by subsurface injection, and these sites operate under permit from the Agency and are carefully inspected.

(c) Surface absorption--Liquid special wastes, including those which are highly alkaline, highly volatile, or highly toxic, may be disposed of by absorption into a completed cell which has been temporarily stripped of final or intermediate cover. This method of disposal may be employed only if subsurface conditions are such that they will allow downward dispersion of the liquid.

(d) Consignment burial--Containerized special waste is permitted for materials that demand the highest degree of caution, and Illinois currently has two such sites which allow for such burial. Heavy equipment traffic must be kept to a minimum and due precaution must be taken to prevent spillage or accidental mixing of incompatible materials.

(e) Land spreading--Land spreading may be permitted at a disposal site either as a method of disposal or as a tool to promote vegetation on completed contours. Such activity is permitted on a case-by-case basis and plans must be submitted that discharging surface water will meet effluent standards. These criteria may be waived at the discretion of the Agency in cases involving emergency response. From time to time, verbal permission may be necessary for disposal of waste generated through episodes or disasters such as pipeline breaks, chemical fills, or storage tank ruptures.

It is difficult in this brief expanse of time to completely outline our current program or to discuss in any thoroughgoing way our proposed criteria for the disposal of liquid and hazardous waste. We are trying to tie in our existing program with new initiatives and pragmatism to develop a program that allows for the disposal of great quantities of society's residue in concert with the development of a state ground-water policy. Such a policy must, as a minimum, address the definition and clarification of legal responsibilities of various state agencies; the definition of major aquifers and guidelines for the protection of these aquifers addressing the question of nondegradation; the development of a statewide water level measurement network for major aquifers, and the development of a statewide ground-water quality monitoring network which would input into a data bank for ground-water quality which would be assessable to all state and interested parties.

We have before us a delicate balancing act, and a weighing of environmental equities which will be a major challenge.

THE ROLE OF INTERSTATE COMMISSIONS IN GROUND-WATER PROTECTION:

THE SUSQUEHANNA RIVER BASIN COMMISSION PERSPECTIVE

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Regional planning for protection of water quality involves complexities that have challenged society for as long as cities have depended upon water-carried systems of waste disposal. The complexities are multiplied when the region involved is in more than one state. This paper will discuss the approaches that are being carried out in a unique institutional setting--that created by the Susquehanna River Basin Compact.

The Susquehanna River Basin Commission and Compact that mandated its being are products of the efforts of an Interstate Advisory Committee established in 1962. The Committee's task was to draft an interstate-federal agreement that would confer administrative and regulatory power on a commission, which in turn would supervise the water resources of the Susquehanna River Basin.

The Interstate Advisory Committee, composed of representatives from New York, Pennsylvania, and Maryland, completed its draft of the proposed Susquehanna River Basin Compact in 1966, and submitted it to the legislative bodies of the involved states. By the end of 1968, the Compact had been approved by the state legislatures and signed by the respective governors. It was then submitted to the United States Congress. After what seemed at times a hopeless struggle in the Congress, the Compact was approved by that body and signed into law by the President on Christmas Eve of 1970.

With the President's signature, the extensive efforts of literally hundreds of persons bore fruit as Public Law 92-575 established authority for the conservation, utilization, development, management, and control of the water and related natural resources of the Susquehanna River Basin under a single, basinwide administrative agency. Under the new Compact, the states of New York, Pennsylvania, and Maryland, and the U.S. Government formally recognize their joint interest and responsibility to provide for effective and economical direction, supervision, and coordination of water resources efforts and programs of federal, state, and local governments and of private enterprise in the basin.

The Commission is composed of four members, one each from the four parties signatory to the Compact. The three governors are the state members while the federal member is an appointee of the President of the United States. To date, the federal member has been the Secretary of the Interior. Each signatory party may appoint an alternate member who, in the absence of the principal member, may vote on issues before the Commission for decision.

With certain exceptions, Commission decisions are made by majority vote. The Commission usually holds meetings once a month with only the alternate members present.

The Commission has a 30-member staff to be headquartered soon in Harrisburg, Pennsylvania. The staff includes engineers, planners, an economist, a geologist, and a biologist. The Commission receives valuable assistance from agencies of the basin states and federal government, and the staff is supplemented by consultants when deemed necessary.

The purpose of the Compact, and the Commission it mandates, is to provide comprehensive planning, administered by a basinwide agency, to effect flood damage reduction; conservation and development of surface and ground-water supply for municipal, industrial, and agricultural uses; development of recreational facilities in relation to reservoirs, lakes, and streams; protection and aid to fisheries; development of hydroelectric power potentialities; improved navigation; control of the movement of salt water; abatement and control of water pollution, and the regulation of stream flows.

The Commission's intended exercise of its authority is articulated in a Comprehensive Plan for the immediate and long-range development and use of the water and related resources of the basin. With specific reference to water quality, the Comprehensive Plan directs the Commission toward coordination of local, state, and federal water-quality management efforts, uniform enforcement, and compliance with established standards.

The Compact assigned the Commission a regulatory role to review certain types of proposed projects. In general, Section 3.10 provides that the Commission's review authority extends to (1) projects that may have an interstate effect on the water resources of the basin, and (2) projects that would affect immediate and long-range alternatives for the management, development, conservation, or utilization of the basin's water resources. When regulations governing Commission review procedures were adopted, it was recognized that agencies of the signatory parties would exercise their review authority and evaluate many of the proposed projects. To avoid duplication of work and enhance intergovernmental cooperation, the Commission and appropriate agencies of the signatory parties executed agreements of understanding that provide for joint review of projects. A permit issued by a signatory agency is considered Commission approval if issued pursuant to such an agreement of understanding and if the project does not contravene the goals or policies of the Comprehensive Plan.

In implementation of its review authority, the Commission from time to time directs the staff to evaluate various review programs of signatory agencies to assure compatibility with the Comprehensive Plan and other Commission policies.

Since the adoption of its regulations for project review, the Commission noted, through the joint review of projects, a growing number of permit applications to the signatory members for discharge of wastewater into the ground. Recognizing that 58 percent of the basin's population depends on ground water as a source of supply, the Commission conducted a review of existing laws, regulations, and programs of the signatories pertaining to underground discharge of wastewater.

From this review of the laws and regulations,[1] it was concluded that the existing requirements of each signatory party appear adequate to protect ground-water aquifers from deep-well injection of wastewater. The regulations are, for the most part, sufficient to protect the ground-water aquifers from shallow wastewater disposal.

Of greater significance, however, is the capability of each member to effectively implement either existing or new regulations and programs aimed at improving the protection of ground waters from shallow underground discharge of wastewater. Not surprisingly, budget and staff limitations were cited as constraints to on-site inspections prior to permit issuance, as well as to follow-up compliance monitoring and surveillance. Although not uncommon, the present system of evaluating projects and permits on a case-by-case basis by each member fails to recognize and address cause-effect relationships on the total basin ground-water resource.

The findings and recommendations of the Commission's review of its members' laws and regulations relating to underground waste discharges are as follows:

> Finding--Past permit applications for industrial wastes have, in some cases, provided inadequate information on the characteristics of the waste, description of the subsurface environment, and the design of disposal systems. Recommendation--Where underground waste disposal is planned, more stringent requirements should be imposed in the submission of information on waste characteristics, subsurface environment, and design of disposal systems as part of the permit application.
>
> Finding--Frequently an applicant is required to perform compliance monitoring with little or no outside verification. This presents a potential problem, especially if dischargers do not have trained personnel or adequate laboratory facilities to reasonably monitor waste discharges. Recommendation--Regulatory agencies require that all analyses of wastewater be conducted by a certified laboratory. Periodic surveillance monitoring by regulatory agencies is also necessary to verify self-monitoring results and assure compliance.
>
> Finding--Evaluation of the disposal area is usually based upon information submitted by the applicant. Recommendation--The permit application process should be less dependent on information provided by the applicant. An on-site evaluation should be conducted by the involved state where toxic or nonbiodegradable substances are apt to be in the effluent.
>
> Finding--Although the state regulatory agencies regulate the use and installation of on-lot septic systems, there are no specific state requirements for dischargers (existing or new) to connect into sewage

treatment systems. *Recommendation*--All signatory parties aggressively encourage dischargers of wastewater that may contain toxic or nonbiodegradable substances (and other wastewater dischargers) to avoid the use of septic systems where municipal sewage treatment systems are available.

Finding--Comments received by signatory states agreed in principle with the recommendation for more comprehensive on-site investigations and monitoring, but noted that funding and staff constraints limited their activities to higher priority projects. The importance of ground water requires maximum assurances that these resources will be preserved for present and future uses. *Recommendation*--Signatory states assure sufficient data is provided for evaluation of permit applications (for both new and existing discharges) and for compliance monitoring to rectify program budget insufficiencies. For example, they could require the discharger to incur a portion of the cost through permit application and compliance monitoring fees, and/or require an applicant to hire a professional consultant to develop the necessary data for permit applications and compliance monitoring.

In January, 1977, the Commission approved follow-up action on the report's findings and recommendations by resolving to: (1) have the state members determine methods to implement the study recommendations; (2) have the Commission involved in future revision and updating by the signatory members of regulations and practices concerning underground disposal of wastewater, in order to improve interstate compatibility, and (3) contact the U.S. Environmental Protection Agency, advising it of the Commission's action and seeking support to implement the Commission's study recommendations.

There is also a need to interface surface and ground-water data for resolving problems, both present and evolving, relative to increased ground-water utilization. There is generally adequate information to tell where ground water may be obtained in the basin, subject always to a final test by drilling. However, information of the type essential for intelligent management of the resource is generally lacking, as is an ample network for the collection of time-related data essential for appraising the effects of man-induced stresses imposed upon the ground-water system. To satisfy these needs to the extent practicable, the Commission has proposed a detailed ground-water investigation for the basin. The ground-water data sought from this study would provide aquifer supply capacities and locations, interrelationships between surface and ground-water quantity, and quality and safe yields.

In summary, the Susquehanna River Basin Commission has the legislative authority to assume jurisdiction to "preserve, protect, improve, and develop the quality of the waters of the basin in accordance with the Comprehensive Plan," with "waters" defined as including both surface and underground waters. However, the Commission has assumed a policy "to encourage and coordinate the efforts of the signatory parties to prevent, reduce, control, and eliminate water pollution and to maintain water quality as required by the Comprehensive Plan." In this role, the Commission at present has chosen to review and evaluate the signatory parties' regulatory programs governing underground waste discharges, rather than assume a more active regulatory role.

Commission concern and action was reflected in the recent adoption of a resolution seeking cooperative action and support by the signatory agencies to: (1) impose more stringent requirements in the submission of information on waste characteristics, subsurface environment, and design of disposal systems as part of the permit application; (2) require all compliance monitoring samples be conducted by a state-certified laboratory; (3) conduct on-site evaluations of proposed disposal areas in cases where toxic or nonbiodegradable substances are a potential in the effluent and require appropriate pre-treatment and stringent monitoring, and (4) assure proper staff evaluation of permit applications by charging a permit application and compliance monitoring fee.

FOOTNOTES

1. Susquehanna River Basin Commission. Assessment of the Water Quality of Streams in the Susquehanna River Basin. January, 1976.

DISCUSSION

Discussion centered on the River Basin Commission's authority to regulate ground-water withdrawal, the cost of making permit application, well-head protection in flood plains, and Commission procedures for protection of water quality.

The Commission has the authority to license new withdrawals that exceed 100,000 gallons per day pursuant to the emergency provisions of the enabling legislation. However, licensing procedures are in effect on a continuous basis to provide information on water use and to provide a standby mechanism for regulation should emergency conditions arise.

The cost of applying for a permit and providing the required data is not known in the case of the Susquehanna Commission, but it was noted that such costs can be a substantial burden on the applicant and create problems for regulatory bodies in terms of processing.

With regard to wells located in flood plains, concern was expressed that floods may result in contamination problems. The Commission has no specific program to require well-head protection, but no evidence that an actual program exists in this area was introduced.

Although the Commission has the authority to take action against a potential polluter directly, it does not exercise this power but instead leaves enforcement to state regulatory agencies. The Commission's role is to review developments that may adversely affect water quality or interstate streams and provide advice to the appropriate agency. This procedure has resulted in project modifications and assists the states in the basin, some of which are understaffed and unable to provide a thorough project review in all cases.

CONVIVIAL TECHNOLOGY AS A LOCAL APPROACH TO GROUND-WATER PROTECTION: THE CHRISTINA RIVER BASIN EXPERIENCE

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Undoubtedly there is going to be a water shortage in the future if present trends of water consumption without conservation continue. Water resources are limited. Only 2.7 percent of all water on the planet is fresh and only .36 percent is easily accessible for potential users. The depletion of aquifers in the West is a continuous problem, irrespective of the current drought, and the contamination of surface waters in the East is forcing many communities into systems that rely on ground-water supplies. It was not until 1974 that loopholes in water laws concerning ground-water quality were plugged. The new legal emphasis lies on ground-water quality. We historically rely on ground water as uncontaminated; subsequently standards for discharges into ground water are higher than for surface water. Yet there is an interrelationship, and periodic exchanges of water occur between streams and aquifers. In our tendency to identify problems and to solve them, one at a time, we sometimes lose an unbiased overview, particularly when solutions are interdisciplinary. In order to implement ground-water resources protection concerns on the local level, we have to develop solutions and regulations that make sense to the local solicitor, municipal engineer, city planner, local official, and special interest groups in a community. As difficult as this might appear as a task, this is essential, since most of the decisionmaking in the U.S. occurs on the local level. Ground-water problems are closely linked to surface-water issues, and solutions can be comprehensive and offer a wide range of benefits. In his book, Design with Nature,[1] Ian McHarg points out that changes and interrelations man introduces into nature can be successful only when they are compatible with the intrinsic attributes to the national systems man is affecting. Examples of interrelated problems to be solved are flooding through runoff increases, stream-bank erosion and aquatic habitat losses, depletion of ground-water supplies, loss of dry weather flow of streams, runoff pollution, and potential ground-water pollution. The local regulatory approach is the adoption of a surface and ground-water drainage code. This was the step taken in the Christina Basin in New Castle County, Delaware.[2]

THE PROBLEM DEFINED

Under natural conditions in Delaware,[3] approximately 10 percent of the total precipitation runs off, approximately 40 percent evaporates or is transpired by plants, and approximately 50 percent infiltrates into the ground (see Figure 1). The proportion of precipitation which runs off, or infiltrates, depends largely on the percentage of impermeable surfaces. Where the coverage of paved surfaces and roofs reaches nearly 100 percent, as in commercial development, runoff may exceed 90 percent and infiltration is virtually nil. Not only is the volume of runoff increased, but also the time of concentration is reduced. This results in a larger peak flow, large storm drainage facilities, and potential flood damage to properties. It also results in stream-bank erosion, loss of vegetation, and the generation of drift solids. Normally, precipitation that infiltrates replenishes ground-water supplies and maintains dry weather stream flow (see Figure 2).

Under natural conditions, contaminated runoff is purified by microbes linked to plants and contained in soil, and is filtered as it seeps into the ground.

FIGURE 1

Typical Hydrograph Changes Due to Increasing the Area of Impermeable Paved Surfaces in a Developing Area

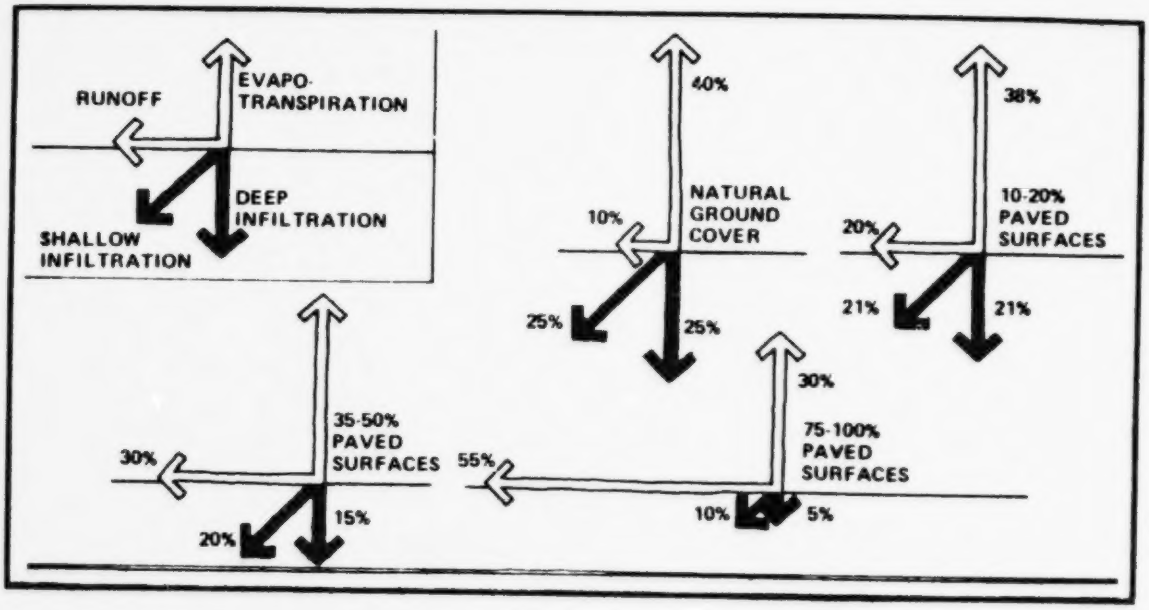
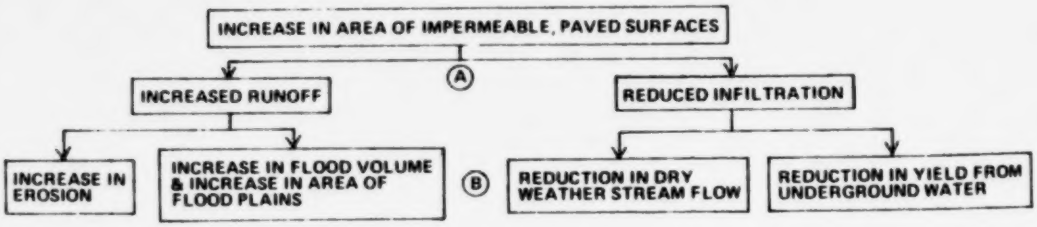

RUNOFF
EVAPO-TRANSPIRATION
DEEP INFILTRATION
SHALLOW INFILTRATION
40%
NATURAL GROUND COVER
10%
25%
25%
38%
10-20% PAVED SURFACES
20%
21%
21%
35-50% PAVED SURFACES
30%
20%
15%
30%
75-100% PAVED SURFACES
55%
10%
5%

FIGURE 2

The Effects of Increasing Areas
of Impermeable Surfaces


INCREASE IN AREA OF IMPERMEABLE, PAVED SURFACES
INCREASED RUNOFF
Ⓐ
REDUCED INFILTRATION
INCREASE IN EROSION
INCREASE IN FLOOD VOLUME & INCREASE IN AREA OF FLOOD PLAINS
Ⓑ
REDUCTION IN DRY WEATHER STREAM FLOW
REDUCTION IN YIELD FROM UNDERGROUND WATER

Unless we maintain these natural processes of purification and infiltration, we will continue to have water resources problems. Solutions should be convivial or life supportive, rather than purely mechanical, and should breach the gaps in engineering-related knowledge relying on the combined expertise of city and regional planners, lawyers, site planners, and engineers.

Problems of reduced infiltration have clear cost implications. The primary aquifer in the Christina Basin is the artesian Potomac Formation, which has a potential total yield of 13 mgd. The amount of water entering the formation is about 12 inches a year over the entire rechargable area, which contains approximately 20,000 acres. This means that under natural conditions 20,000 acre feet/year or 55 acre feet/day are infiltrating the aquifer. Thus, approximately 9,000 acres may be lost to urban development until water-supply problems become serious. At this point we have three alternatives:

1. Keep the remaining undeveloped recharge area in its natural state (Figure 3). To do this effectively, it would be necessary to buy the land. At an approximate cost of $5,000 per acre, this would require an investment of $55 million. Spread over 20 years, the cost of water would be $250 per acre foot.

2. Provide water from alternate sources. The cost of providing water from a surface water reservoir might be about $60 per acre foot (Figure 4).

3. Allow development, providing protection measures were taken to keep infiltration at its natural level (Figure 5).

Alternative 3 is the most lucrative, particularly if additional benefits of reducing runoff and flood problems through infiltration devices are considered.[2]

To be compatible with a surface-water reservoir, ground-water development

FIGURE 3

Aquifer Recharge Can Be Maintained
by Keeping the Remaining Recharge Area in a Natural State

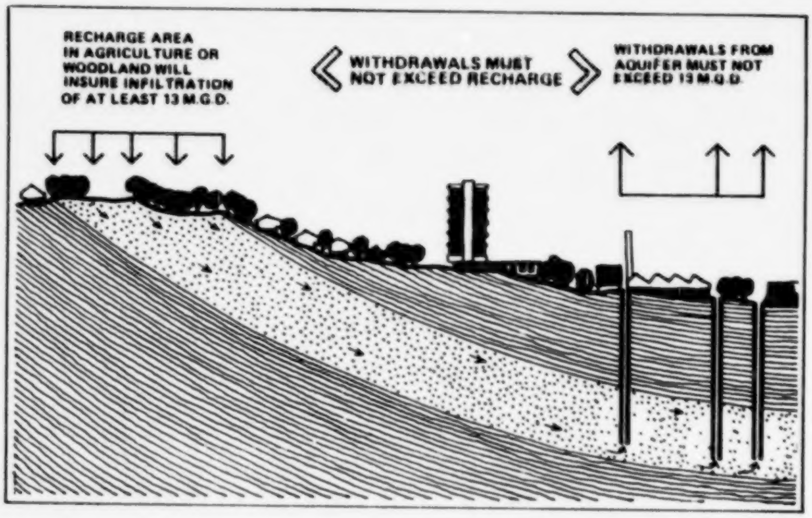

RECHARGE AREA IN AGRICULTURE OR WOODLAND WILL INSURE INFILTRATION OF AT LEAST 13 M.G.D.
WITHDRAWALS MUST NOT EXCEED RECHARGE
WITHDRAWALS FROM AQUIFER MUST NOT EXCEED 13 M.G.D.

FIGURE 4

The Remaining Recharge Area Can Also be Developed
Providing that Infiltration Devices
are Incorporated into Development

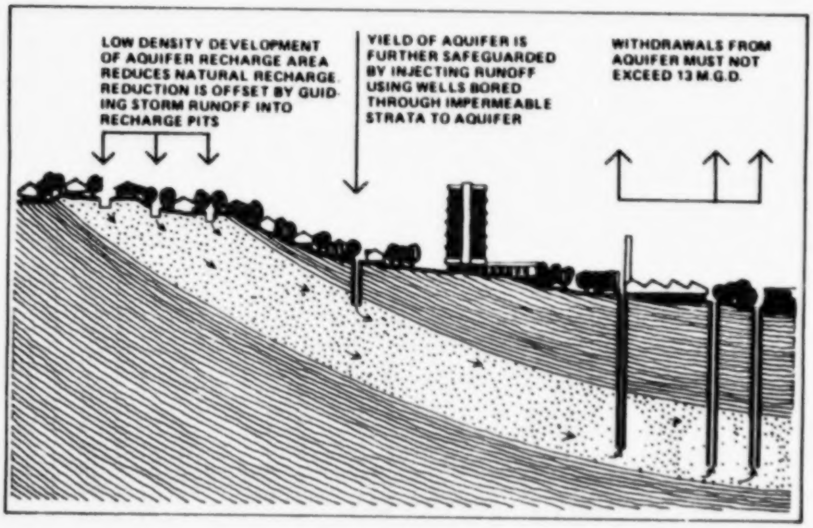
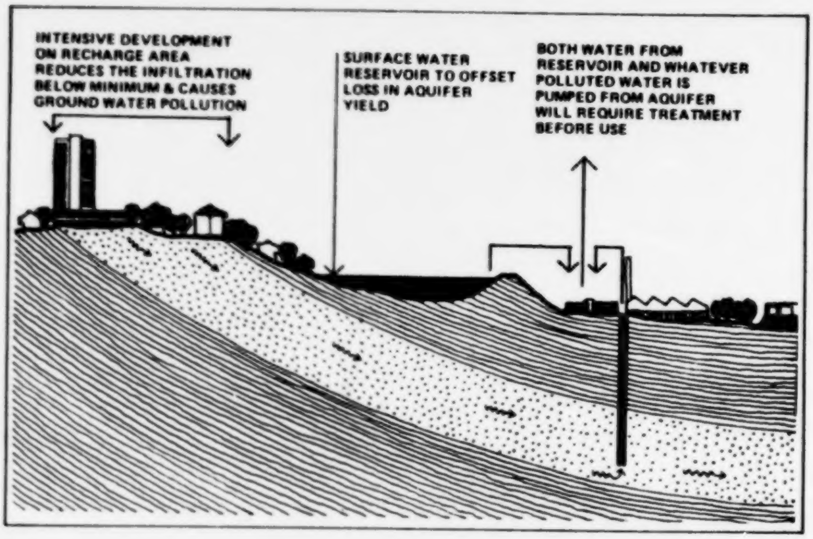

LOW DENSITY DEVELOPMENT OF AQUIFER RECHARGE AREA REDUCES NATURAL RECHARGE. REDUCTION IS OFFSET BY GUIDING STORM RUNOFF INTO RECHARGE PITS
YIELD OF AQUIFER IS FURTHER SAFEGUARDED BY INJECTING RUNOFF USING WELLS BORED THROUGH IMPERMEABLE STRATA TO AQUIFER
WITHDRAWALS FROM AQUIFER MUST NOT EXCEED 13 M.G.D.

FIGURE 5

Intensive Development of the Recharge Area
Will Require a Water Supply From Alternative Sources


INTENSIVE DEVELOPMENT ON RECHARGE AREA REDUCES THE INFILTRATION BELOW MINIMUM & CAUSES GROUND WATER POLLUTION
SURFACE WATER RESERVOIR TO OFFSET LOSS IN AQUIFER YIELD
BOTH WATER FROM RESERVOIR AND WHATEVER POLLUTED WATER IS PUMPED FROM AQUIFER WILL REQUIRE TREATMENT BEFORE USE

should not cost more than $60 per acre foot or $876,000 for the full 13 mgd. capacity of the Potomac Formation. Water companies that draw on this groundwater supply could be assessed a user charge, which could be paid as an incentive to developers who install infiltration devices as part of their development.

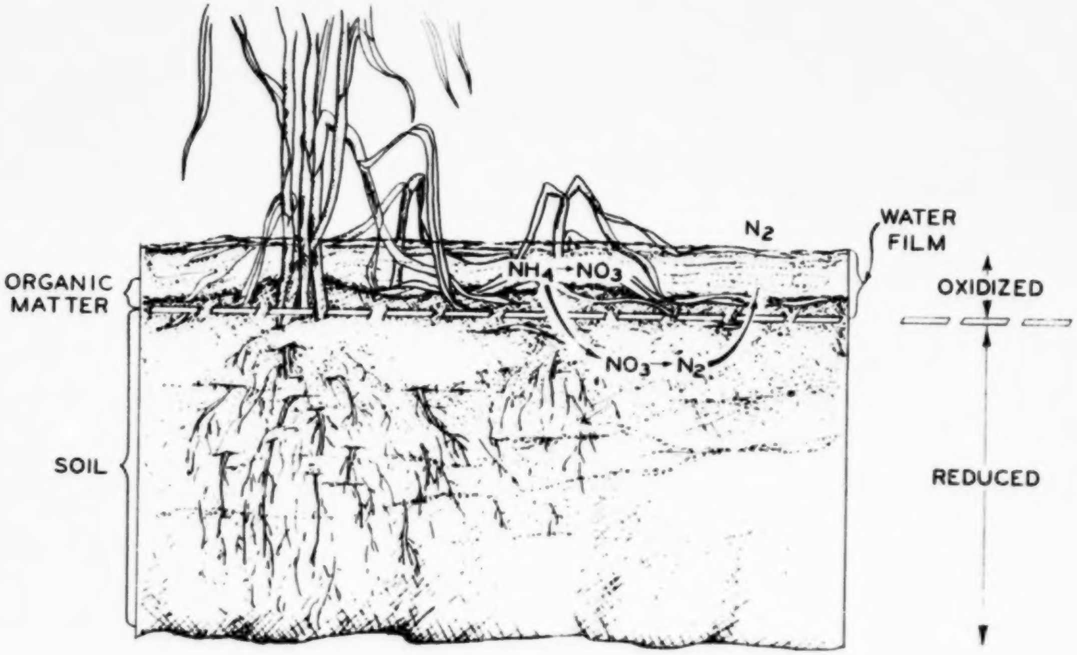
ALTERNATIVE TECHNOLOGY

There are technological alternatives that are aesthetically acceptable, ecologically sound, and socially beneficial. Subdivision regulations in many communities, for example, require that stormwater be collected and piped into streams. Instead, communities should consider alternatives that would meet the objectives of maintaining infiltration and improving water quality. Following are examples of techniques that can be employed to meet this objective.

Runoff Quality Improvement Through Overland Flow, Prior to Infiltration

Overland flow is used as a treatment process for municipal wastes[4] and certainly is adaptable for the treatment of polluted runoff if it would be permitted to flow across the vegetated surface of sloping terrain. Renovation is accomplished by physical, chemical, and biological means. When water is applied regularly, both aerobic and anaerobic processes occur in overland flow systems (Figure 6). Runoff can be collected at the foot of slopes in shallow ditches and directed to infiltration devices if water quality is acceptable.

FIGURE 6

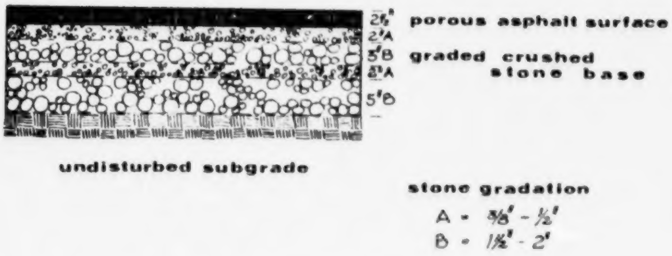


N_2
WATER FILM
ORGANIC MATTER
$NH_4 \rightarrow NO_3$
OXIDIZED
$NO_3 \rightarrow N_2$
SOIL
REDUCED

Infiltration of Precipitation "at Source" Through Porous Paving Asphalt[5]

When runoff from "clean land uses" is infiltrated prior to concentration, many contamination problems do not occur. Porous paving asphalt has been developed to permit infiltration through its surface and a crushed stone base, and has proven to be practical (Figure 7).

FIGURE 7


2½"
2"A
5"B
2"A
5"B
porous asphalt surface
graded crushed stone base
undisturbed subgrade
stone gradation
A - 3/8" - ½"
B - 1½" - 2"

as used at the University of Delaware, Newark, Delaware

At-Source Infiltration Through Lattice Blocks[5]

There are various forms of modular pavers that can be set in sand on a crushed stone base to permit infiltration (Figure 8) and may even be covered with grass (Figure 9).

FIGURE 8

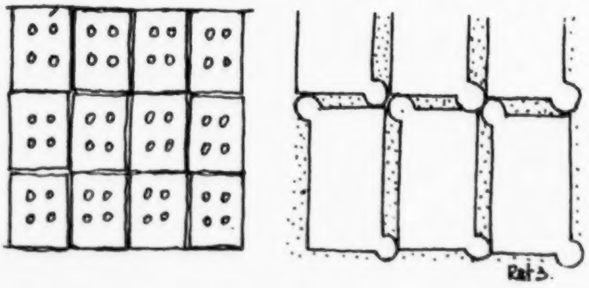
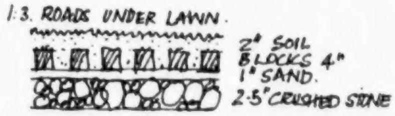


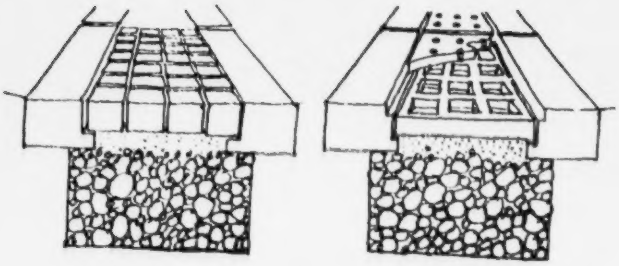
FIGURE 9


1:3. ROADS UNDER LAWN.
2" SOIL
BLOCKS 4"
1" SAND.
2·5" CRUSHED STONE

At-Source Infiltration Through Dutch Drains[5]

Gravel-filled ditches with optional drainage pipe in their base and seepage beds can be arranged to intercept "sheet" runoff prior to concentration (Figure 10).

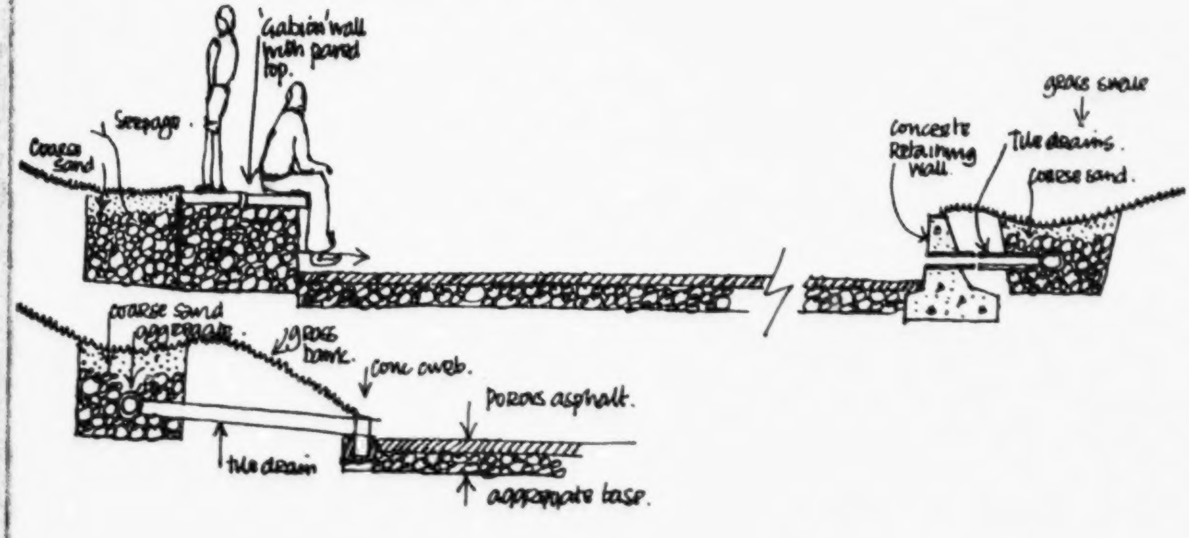
FIGURE 10



Infiltration of Runoff After Preliminary Concentration Through Seepage Areas[5]

Seepage areas can take the form of pits, trenches, or tile fields, and can be arranged for multi-purpose use such as the porous pavement basketball court shown in Figure 11.

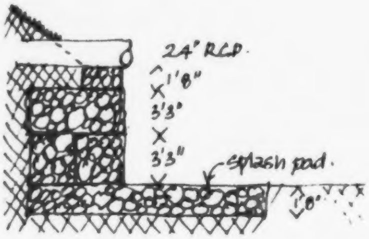
FIGURE 11


'Gabion' wall with paved top.
Seepage.
Coarse sand
Concrete Retaining wall.
grass swale
Tile drains.
coarse sand.
coarse sand
aggregate.
grass bank.
conc curb.
Porous asphalt.
tile drain
aggregate base.

Infiltration of Runoff After Preliminary Concentration Through Recharge Basins[6]

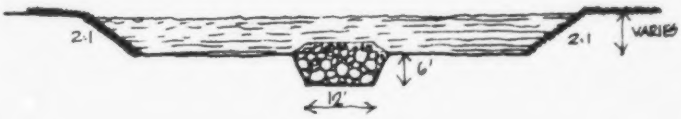
Basins are deeper than seepage areas and operate under a greater head, and therefore are capable of recharging a greater volume of water per unit area in a given time. Retaining walls can be constructed of gravel-filled wire baskets (Figure 12) and percolation can further be enhanced through gravel-filled trench drains (Figure 13).

FIGURE 12



Sectional detail of retaining wall and inlet pipe showing splash pad and use of gabions.

FIGURE 13



EXISTING REGULATIONS

The Safe Drinking Water Act of 1974[6] strengthens the Water Pollution Control Act Amendments of 1972[7] concerning the protection of ground water and aquifer recharge areas. Section 1442(a)(1)(E) requires EPA to develop "improved methods of protecting underground water sources of public water systems from contamination." Section 1442(a) requires the administrator of EPA to carry out a "study of the nature and extent of the impact on underground water which supplies or can reasonably be expected to supply public water systems." In aquifer recharge areas, the intent is to reduce "(b) intensive application of pesticides and fertilizers in underground water recharge areas; and (c) ponds, pools, lagoons, pits, or other surface disposal of contaminants in underground water recharge areas."

EPA, as the administrator of both laws, is a regulatory agency that oversees federal activities according to the provisions of various laws, and carries out research. Decisions concerning land use in the U.S. are, however, being made on the local level, and it is land use that affects the quality of ground-water recharge and its contamination through point and non-point sources.

MUNICIPAL ACTION FOR GROUND-WATER RESOURCES PROTECTION

Municipalities have established land use regulations and review and approval procedures for development proposals that permit ground-water resources protection. These procedures and regulations are similar throughout the United States and linked to local planning and zoning. Any serious attempt to protect ground-water resources thus will have to be aimed at the local level.

Development proposals that are submitted for approval are reviewed for conformance with adopted comprehensive plans, zoning ordinances, and subdivision regulations. This review can involve the planning commission, zoning board, municipal engineer, soil and water conservation district, neighborhood associations, and various experts any of the agencies mentioned above would want to bring in. Land use controls in the U.S. are in a slow process of change from Euclidian zoning, where the best use for a site is determined in advance, to performance controls, which rely on a case-by-case review. Performance controls are aimed at maintaining natural processes, leaving it up to the developer to choose the techniques that guarantee that certain standards are met.[8]

The New Castle County Surface and Ground-water Drainage Code and its Amendments[2] are an example of how objectives are implemented through measures which developers can take when it comes to stormwater detention, streambank stabilization, and erosion and sedimentation control, among others.

It is recommended that municipalities develop policies and set standards concerning the following:

1. Non-point source pollution abatement, including controls for urban sources, construction-related sources, agriculture, mining, hydrologic modification, and saltwater intrusion.

2. Inducement of infiltration of precipitation into the ground and the subsequent reduction of runoff from paved surfaces.

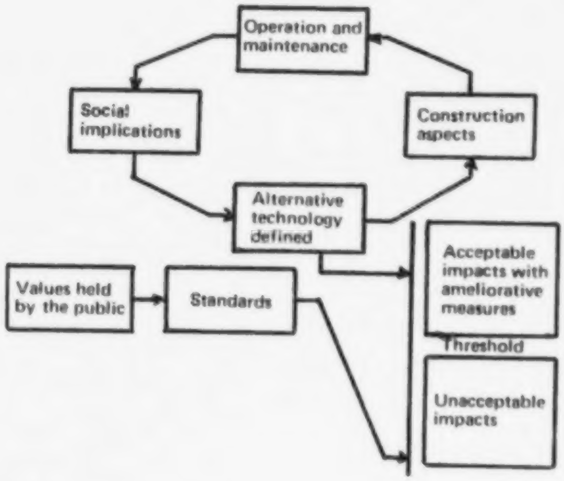
It is further recommended that municipalities expand the review procedure to require that the developer analyze alternative technical solutions for the reduction of potentially adverse environmental impacts, and that this process include the following steps (see also Figure 14):

1. Alternative Technology Defined--Technological alternatives to maintain infiltration reduce runoff and improve runoff quality should be defined and analyzed for the following:

2. Construction Aspects--The site requirements of various infiltration devices will vary. Porous pavement, for example, requires a well-drained soil, while seepage pits will be able to penetrate impervious clay lenses. So will there be variations in material and equipment needs. Some devices can be entirely constructed from local materials, which is a benefit. What will happen to facilities once they are obsolete should be a concern prior to construction. There will also be considerable variations in capital and labor requirements that need

FIGURE 14

Procedure for Alternative Technology Analysis and Environmental Impact Assessment


Operation and maintenance
Social implications
Construction aspects
Alternative technology defined
Acceptable impacts with ameliorative measures
Threshold
Unacceptable impacts
Values held by the public
Standards

to be assessed.

3. Operation and Maintenance--The maintenance cost of a system and its labor requirements and efficiency of operation should be considered, along with its ability to perform with a minimum investment of resources.

4. Social Implications--This includes considerations of public health implications of potentially adverse environmental impacts and an identification of who suffers and who benefits through its implications.

5. Values, Standards, and Acceptable Impacts--The outcome of the analysis described above and its rating will depend upon values held by the public. Community objectives and performance standards, such as "zero runoff increases" are formed through a policy-determination process. The performance of alternative systems can then be judged against such development standards which will help to decide whether a proposed use has an acceptable or unacceptable impact and whether it is convivial--implying that it is culturally, socially, and ecologically sound. Implementation of policies would offer the following benefits to the community:

a. Protection of ground-water recharge and ground-water supplies for public needs.

b. Prevention of water pollution from non-point sources and the resulting adverse effects on public health and safety.

c. A reduction in the volume, frequency, and velocity of local flooding and associated flood damage.

d. Maintenance of dry weather flow in streams.

e. Enhancement of aquatic habitats by preventing temperature increases through runoff, channel enlargement, loss of shade trees through streambank erosion, loss of fish, and the degradation of a recreational resource.

f. A saving of public expenditures for stream channelization as an ill-fated device to contain stormwater flow.

Land use decisions in the U.S. are being made on the local level. In order to implement ground-water resources protection measures locally, associated benefits need to be communicated to the public. Obviously this has not been done effectively enough; otherwise we would have more examples of adopted ordinances. The only way to bring about effective local control is not to separate water issues, and to establish neighborhood care programs and ordinances that address themselves to interrelated problems posed by reduced infiltration and ground-water recharge, stormwater management, and the control of non-point sources of water pollution.

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4. Joachim Tourbier and Robert W. Pierson, Eds., Biological Control of Water Pollution. University of Pennsylvania Press, 1976.

5. Joachim Tourbier and Richard Westmacott, Water Resources Protection Measures in Land Development--A Handbook. University of Delaware Water Resources Center, 1974.

6. The Safe Drinking Water Act, P.L. 93-523.

7. The Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500.

8. Charles Thurow et al, Performance Controls for Sensitive Lands: A Practical Guide for Local Administrators. U.S. Environmental Protection Agency, 1975.

DISCUSSION

The discussion related to the issue of incentives for local action to protect the ground-water resource. Attention was given to the impediment to local action that exists where benefits of programs for protecting the quality and quantity of ground-water recharge accrue to another community. Since the costs of protection programs can be substantial, they are not likely to be undertaken voluntarily under such conditions. Therefore it may be necessary in a particular case for a higher unit of government to impose a penalty for development in one area having an adverse impact in another. Alternately, an incentive approach such as a tax advantage may be employed to encourage protection programs having extraterritorial effects. Another approach is to identify the on-site benefits of protection programs. For example, programs to facilitate ground-water recharge may reduce floodwater problems and enhance general environmental conditions of the area where adopted.

Institutional Arrangements for Ground Water Protection

INSTITUTIONAL REQUIREMENTS FOR GROUND-WATER PROTECTION:

THE NATIONAL WATER COMMISSION VIEW

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The National Water Commission (NWC) was established pursuant to Public Law 90-515[1] approved September 26, 1968. The Commission consisted of seven members appointed by the President. There were a number of changes in membership of NWC during its five-year life. Charles F. Luce served as Chairman throughout. The author served as one of the nine principal consultants to NWC.

The statutory charge to the Commission was:

> "The Commission shall (1) review present and anticipated national water resource problems, making such projections of water requirements as may be necessary and identifying alternative ways of meeting these requirements--giving consideration, among other things, to conservation and more efficient use of existing supplies, increased usability by reduction of pollution, innovations to encourage the highest economic use of water, interbasin transfers, and technological advances including, but not limited to, desalting, weather modification, and waste water purification and reuse; (2) consider economic and social consequences of water resource development, including, for example, the impact of water resource development on regional economic growth, on institutional arrangements, and on esthetic values affecting the quality of life of the American people; and (3) advise on such specific water resource matters as may be referred to it by the President and the Water Resources Council.

NWC considered a wide variety of subjects relating to the water resources of the nation, and to water resource development and utilization. The Commission gave considerable emphasis to management of ground-water resources and protection of ground-water quality. Some 64 separate studies were conducted by Commission staff and consultants (Ref. 1). Of particular interest here are reports on state water laws (Ref. 3), on ground-water law, management, and administration (Ref. 4) and on ground-water management (Ref. 5).

The Commission completed its work and submitted its final report to the President and the Congress on June 14, 1963 (Ref. 1), and a summary report incorporating conclusions and recommendations on June 28, 1973 (Ref. 2).

NWC VIEWS ON GROUND WATER

The following relevant excerpts (emphasis added) from the NWC summary report (Ref. 2) summarize the Commission's views and conclusions respecting the nation's ground-water resources:

> (From pp. 61-63)
>
> "In many States, ground water law, like riparian surface water law, is inadequate to allocate the resource among competing users and is unresponsive to the problem of excessive use. The first defect results from the vagueness of the rules of allocation ("reasonable use") and the second from the failure of the legal system to perceive that ground water is often a common-pool resource in which there is little incentive to save an exhaustible supply for use tomorrow. Any user who seeks to save is subject to having his savings captured by another pumper from the same aquifer. It is the Commission's recommendation that a new legal system to govern ground water should be instituted in States where better management of ground water is needed.
>
> "Laws should be enacted authorizing the establishment of water management agencies with power to manage surface and ground water supplies conjunctively, to coordinate surface and ground water withdrawals, to control the rate at which an aquifer is depleted (through pump charges or quotas on withdrawals), to replenish aquifers by artificial recharge techniques, and to protect aquifers from pollution.
>
> "Apart from pollution control guidelines comparable to those which apply to surface water, the Commission does not believe that Federal regulation of ground water is desirable, but it does hold that the adequacy of the ground water management system is relevant to the need for Federal projects to supply supplementary water to overdrawn basins, and recommends that a description and evaluation of such ground water management systems be incorporated into reports to Congress on proposed projects for supplying additional water to such basins."
>
> (From p. 109)
>
> "Although it has not received as much attention as surface water pollution, ground water pollution may be more significant. Because surface water and ground water are so often interrelated and because the same water quality control expertise must often be applied to both, the agencies which monitor and enforce surface water pollution controls should be responsible for ground water pollution abatement as well, at both the Federal and State levels.
>
> "Another problem stems from the fact that one ground water pool

> may underlie two or more States. Little law has been developed for the regulation and management of such interstate aquifers. It is clear that interstate aquifers should be managed and regulated in the same fashion as intrastate aquifers. To do so, it is desirable that States enter into arrangements with one another to permit appropriate management and regulation of interstate aquifers.
>
> "Finally, it is apparent that there is a deficiency in the amount of technical data and other information about ground water resources, information which is needed to make sound decisions with regard to regulation and management."

Recommendations

The Commission's recommendations specifically relating to regulatory control of ground-water quality (Ref. 2, pp. 78-79) are as follows:

> "4-1. The Nation's water pollution control policy should be based on the principles that (1) water is polluted when its quality has been altered by the activities of man to such a degree that reasonable present and prospective uses as designated by public authorities are impaired, and that (2) the objective of pollution control should be to protect the designated uses. The 1972 Act should be revised to restore these policies.
>
> "4-2. Receiving water standards should be established under the principles stated in 4-1, above, for all State waters, including ground waters. Standards should be sufficiently high to protect all existing uses and all reasonably foreseeable future uses, but should also take into account the economic, social, and environmental costs of achieving them.
>
> "4-9. Water quality standards should be implemented through a national waste discharge permit system, administered by State authorities under Federal guidelines. . . ."

NWC presented 20 recommendations concerning overall management of ground-water resources (Ref. 2, pp. 109-112). They are the following:

> "7-1. State laws should recognize and take into account of the substantial interrelation of surface water and ground water. Rights in both sources of supply should be integrated, and uses should be administered and managed conjunctively. There should not be separate codifications of surface water law and ground water; the law of waters should be a single, integrated body of jurisprudence.
>
> "7-2. Where surface and ground water supplies are interrelated and where it is hydrologically indicated, maximum use of the

combined resource should be accomplished by laws and regulations authorizing or requiring users to substitute one source of supply for the other.

"7-3. The Commission recommends that States in which ground water is an important source of supply commence conjunctive management of surface water (including imported water) and ground water through public management agencies.

"7-4. The States should adopt legislation authorizing the establishment of water management agencies with powers to manage surface water and ground water supplies conjunctively; to issue revenue bonds and collect pump taxes and diversion charges; to buy and sell water and water rights and real property necessary for recharge programs; to store water in aquifers, create salt water barriers and reclaim or treat water; to extract water; to sue in its own name and as representative of its members for the protection of the aquifer from damage, and to be sued for damages caused by its operations, such as surface subsidence.

"7-5. The States should adopt laws and regulations to protect ground water aquifers from injury and should authorize enforcement both by individual property owners who are damaged and by public officials and management districts charged with the responsibility of managing aquifers.

"7-6. Any Federal agency seeking authorization of a Federal water project for an area having a usable ground water aquifer should describe and evaluate the ground water management programs in the areas.

"7-7. Where ground water mining is occurring, the States themselves (or local management agencies) should immediately institute regulation of ground water withdrawal and conjunctive management of ground water and surface water, where the latter source of supply is available. Regulation and management can include levying of pump taxes, or implementation of quota restrictions with freely transferable pumping rights, or some other means, and should have as its purpose conservation and prudent use of the water resource. It can also include artificial recharge, improving infiltration capacity, and other management activities. It should take account of the value of present uses as compared to the estimated value of future uses, the desirability of preserving some ground water for future use irrespective of estimated future value, and such effects on the aquifer system from rapid depletion as loss of storage capacity and reduced transmissivity.

"7-8. The President should issue an executive order directing Federal agencies charged with responsibility of water resource planning and development to include in all pertinent studies and project proposals a description of the ground water resource, whether or not ground water is being mined and, if so, the regulatory and management regime applicable to it, together with an evaluation of that regime.

"7-9. Congress should scrutinize closely the economic justification for water supply projects designed to supply supplementary water to areas that have mined ground water and should examine the circumstances giving rise to the project proposal including the presence or absence of ground water regulation and management, and their operation.

"7-10. Funds should be granted to the U.S. Geological Survey to increase its study of ground water pollution, the causes thereof, and the relationship between surface water pollution and ground water pollution. The USGS should monitor ground water quality, giving priority to aquifers threatened by impairment of quality.

"7-11. The States should regulate the drilling, completion, operation, and abandonment of wells for the purpose of protecting ground water quality. Well drillers should be licensed, permits should be required before drilling is permitted, and drilling and completion reports (including well logs where appropriate) should be required.

"7-12. The regulation of ground water quality by the States should be the responsibility of the same agencies that regulate surface water quality.

"7-13. A State agency should be responsible for identifying the adverse effects on ground water quality resulting from land use, and the States, or governmental subdivisions thereof, should regulate land use among other purposes so as to control or eliminate such adverse effects.

"7-14. Any report on a water supply project proposed by a Federal agency should contain a full description of the quality of the local ground water, its suitability for use, the deterioration that has occurred in the last 20 years (if data are available), the ground water quality control program applicable in the area, and its adequacy.

"7-15. Federal legislation on control of surface water pollution should be expanded to include ground water pollution, and the regulatory regime and enforcement techniques at the Federal level should be the same for both surface and ground water.

"7-16. The U.S. Geological Survey should make continuing intensive investigation of significant aquifer systems giving priority to those with falling water tables and deteriorating water quality. The investigations should seek to determine:

a. aquifer boundaries, thickness, saturation, and transmissivity;

b. the suitability of overlying land and wells for artificial recharge programs;

c. depth of water, quality and temperature of water;

d. the storage capacity at various ground water levels;

e. the source of pollutants found in the aquifer;

f. natural discharge from the aquifer, principal withdrawals, sources and amounts of recharge, anticipated yields, and the effect of pumping on surface supplies;

g. the extent of past ground water mining and the estimated economic life of the aquifer under various assumptions as to rates of withdrawal; and

h. the susceptibility of the aquifer to operation and management on a "sustained yield" basis.

"7-17. Federal appropriations for the Federal-State cooperative study programs should be increased to meet the amount of matching funds available from the States.

"7-18. The U.S. Geological Survey (USGS) should report the results of these investigations to the Congress, the Water Resources Council, the Office of Management and Budget, the Environmental Protection Agency, the Governors, State engineers (or their equivalents), and state water quality control agencies of the affected States, and local officials, including city councils, county officials, and local water management officials.

"7-19. On the basis of data received from the USGS, the Water Resources Council should formulate recommendations for improved ground water management practices and transmit its recommendations to appropriate Federal, State, and local officials.

"7-20. Federal and State courts should be empowered to obtain the services of the USGS in water litigation for water supply and quality investigations, and these services should be available at cost, subject to the availability of personnel and other resources to conduct the investigations."

In summary, the National Water Commission recommended:

1. Comprehensive conjunctive management of surface and ground-water resources under state law, including quality control.

2. Extension of the regulatory and enforcement authority of the

Environmental Protection Agency under the Federal Water Pollution Control Act, as amended (P.L. 92-500), to ground waters but with a more rational basis for setting water-quality standards.

3. Increased emphasis on protection of ground-water quality.

4. Vesting of primary responsibility for ground-water quality control in the states under federal guidelines.

5. Enactment of comprehensive state statutes for control, protection, and management of surface and ground waters on an integrated basis.

6. Creation of public water resource-management agencies with broad powers under state law.

7. Greater attention by Congress and the federal agencies to ground-water problems, protection, and management under federal water-resource programs.

8. Regulation of land use by the states or local political subdivisions as necessary, among other purposes, to control or eliminate adverse effects on ground-water quality resulting from land uses.

In the author's opinion, NWC did not give adequate attention to non-point sources of pollution nor to the extensive institutional re-structuring at both the federal and state governmental levels necessary to carry out the Commission's concept of comprehensive water-resource management.

FEDERAL STATUTES AND PROGRAMS FOR GROUND-WATER QUALITY CONTROL

Other papers presented here discuss the relevant federal statutes and programs in depth. Suffice it to say that there does exist at the federal level some degree of authority to control and protect ground-water quality, but there is no general federal authority to manage the nation's ground-water resources on a comprehensive basis.

The Federal Water Pollution Control Act, as amended (P.L. 92-500), does contain a number of provisions relating to ground water. These, however, pertain mostly to monitoring, planning, and development of criteria and guidelines for preventing and abating pollution of ground waters. EPA has little direct regulatory or enforcement power as regards control of ground-water quality, except with respect to disposal of pollutants through wells.

The Safe Drinking Water Act of 1974[2] provides for control by EPA, acting through the states to the extent possible, of underground injection of pollutants (Part C, Sec. 1421 et seq). Under Sec. 1424(e), the EPA Administrator can act to protect the recharge zone of an aquifer which is the sole or principal source of drinking water for an area. The Act provides (Sec. 1442) for research and studies of sources of pollutants and means of preventing contamination of underground water supplies.

The Resource Conservation and Recovery Act of 1976[3] and the Toxic Substances Control Act of 1976[4] provide EPA with authority to prevent pollution of ground waters from certain sources of pollutants such as solid waste and disposal of waste-treatment sludges.

However, none of the federal statutes provide authority for EPA or any other federal agency to manage or to mandate comprehensive management of ground-water resources. The federal water-development programs, such as those of the Bureau of Reclamation and Corps of Engineers, which are generally concerned only with surface waters, often have an adverse effect on ground-water quality.

STATE STATUTES AND REGULATIONS

In a report prepared for EPA in 1973 concerning federal and state statutes and regulations for control of ground-water pollution (Ref. 6, p. 1), Geraghty & Miller, Inc., concluded:

> "The statutes and regulations of Federal and State agencies vary widely as to objective, scope, and detail in providing for control of groundwater pollution. State water and water pollution statutes tend to deal primarily with surface water; only 13 States were found to have water statutes dealing specifically and extensively with groundwater quality. However, in a broad sense, all of the States appear to have legislation under which may be undertaken measures found necessary for the protection of groundwater quality."

Typically in any state, several state agencies have responsibilities for control of activities that may adversely affect ground-water quality, each agency having its individual "piece of action." A mechanism for full coordination of these disparate responsibilities to achieve a more comprehensive approach is often lacking.

California has a comprehensive water quality control statute[5] under which the quality of ground waters can be protected from deterioration resulting from waste discharges and certain other of man's activities. The State Water Resources Control Board and Regional Water Quality Control Boards have acted effectively in this regard. However, California has no body of statutory law respecting the development and utilization of the state's ground-water resources. A high level of conjunctive management of surface and ground waters is being achieved in several areas of the states, but this is the result of local initiative or of court mandates resulting from adjudication of ground-water rights.

The recent hearing by the House Interior and Insular Affairs Committee on the Central Arizona Project (one item on the Carter Administration's so-called "hit" list) brought out the fact that Arizona still does not have a ground-water code. The project, which will be in the billion-dollar category, was authorized in 1968 to import Colorado River water as a means of partially alleviating the long-continued ground-water overdraft which amounts to more than two million acre feet per year.

It is not known which, if any, of the states have strengthened their statutes, regulations, and agency activities for protection of ground-water quality since 1973. To the best of the author's knowledge, no state has yet enacted a body of law under which comprehensive, integrated management of surface and ground waters, in both quantity and quality, could be achieved.

NEED FOR COMPREHENSIVE MANAGEMENT

Ground-water quality may be degraded due to a wide spectrum of sources and causes, some natural and many due to man's activities. Development and utilization of the ground-water resource itself may result in quality deterioration--from overpumping, for example. Changes in the characteristics of surface-stream flows frequently adversely affect ground-water quality.

Protection of ground-water quality cannot be fully achieved solely by regulation and control of disposal of wastes or by regulation of the construction and abandonment of wells. Only through comprehensive, conjunctive management of surface and ground waters can the full benefit of these resources, with adequate protection of quality, be achieved.

CONCLUSIONS

The recommendations of the National Water Commission offer a sound basis for management of the nation's ground-water resources, including protection of ground-water quality. However, it appears that little has been done to implement those recommendations since the Commission's report in 1973.

RECOMMENDATIONS

The first steps toward full implementation of the Commission's recommendations should include:

1. Encouraging each state, perhaps through incentives, to enact the necessary body of law and to revise the state agency structure in order to achieve comprehensive, integrated management and control of the state's water resources, surface and underground.

2. Reviewing and revising as necessary the several federal water-resource programs to accord with the concept of comprehensive water-resource management.

FOOTNOTES

1. 82 Stat. 868, 42 USCA 1962a, note (1971 Supp).

2. Public Law 93-523, 88 Stat. 1660.

3. Public Law 94-580, 90 Stat. 2795.

4. Public Law 94-46; 90 Stat. 2803.

5. Porter-Cologne Water Quality Control Act, as amended, Division 7, Water Code.

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4. Corker, Professor Charles E., University of Washington, Ground Water Law, Management and Administration. 1971. NTIS Accession No. PB 205-527.

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7. Lehr, Jay H., et al, A Manual of Laws, Regulations and Institutions for Control of Ground Water Pollution. Prepared for U.S. Environmental Protection Agency, June, 1976, NTIS Accession No. PB 257-808.

DISCUSSION

Discussion focused on four major areas: the need for flexibility in ground-water quality standards; obstacles to revision of state institutions; need for incentives for state institutional revision, and management philosophy with regard to allocation of ground water over time.

Emphasis was given to the fact that ground-water quality standards cannot be uniform but must be site-specific in terms of geographical location and nature of water use. The principal example used was the salt build-up problem common on western irrigated lands but non-existent in many other areas.

Common law and judicial attitudes were viewed as a basic impediment to needed revisions in state institutional structures for water resources management. However, this factor was not viewed as insurmountable and examples were given wherein major modifications had been accomplished or currently were under consideration.

The issue of incentives to encourage change in state institutions to achieve more effective water management was related to the question of whether federal money should be spent to rescue an area where a water crisis is due in part to failure of the local people to protect the resource. The viewpoint was expressed that improved management should be established as a condition precedent to federal involvement in development projects.

The discussion of management philosophy was concerned with the distinction between programs designed to maintain the ground-water resource for indefinite use and those based on a set life after which the resource will be exhausted. It was pointed out that either may be appropriate under particular circumstances, but that a conscious choice between the two should be made in full awareness of the consequences. Where the set-life approach is adopted, major economic and social disruptions are a future possibility, since the area may have to be abandoned or utilized for a different activity such as dry-land as opposed to irrigated farming. Importation of water may prevent such disruptions and appear to be an underlying assumption in some areas where mining of ground water is employed. It was noted that Congress has authorized a study of the feasibility of maintaining the irrigated agriculture economy of the high plains region of Texas and several other states where mining is being practiced.

INSTITUTIONAL REQUIREMENTS FOR GROUND-WATER PROTECTION:

THE NATIONAL WATER WELL ASSOCIATION VIEW

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Believing that the nation's water could all be cleaned by a central filter placed in the nation's capitol is about as ludicrous as believing that viable solutions to pollution can be developed in Washington's teeming bureaucratic jungle far removed from the heartland of America's water supply. But too often the imperial directives handed down from the hallowed halls of Congress require no less simplistic solutions. As John Parkhurst said last December, inflexibility produced by including detailed administrative requirements and time tables defeats the efficient achievement of the goals and objectives we all share.

It is no wonder that the Environmental Protection Agency continually opts for the hiring of professional bureaucrats, rule makers, and regulators at its Washington headquarters in lieu of highly qualified professional scientists. It takes nothing less than a bureaucrat to cope with the myriad requirements mandated in public laws, whether they be P.L. 92-500 (Water Pollution Control Act), P.L. 93-523 (Safe Drinking Water Act), P.L. 94-469 (Toxic Substances Control Act), or P.L. 94-580 (Resource Conservation and Recovery Act).

EPA's top administrators recognize that these unyielding requirements tend to strangle many dedicated scientists who, in turn, shun this hectic and exasperating atmosphere. The result is an increase of bureaucrats in Washington and a concurrent expansion of the scientific community throughout state governments. That the two groups must compliment each other as they work together is obvious to even the most naive Washington watcher, yet full cooperation is rarely achieved.

While tremendous credit is due those who direct the implementation of all the aforementioned pieces of legislation for drawing into the equation a broad cross-section of America through public meetings and requests for written comment, one has to wonder whether anyone really listens when "hearings" are held.

I honestly believe that there is less need today for federal regulation of our nation's water than any time in our history. Fifteen years ago, when a company was likely to locate where it could best get away with dumping its wastes in the nation's waters, a federal mandate upon each and every state was a strategic necessity. Today an environmentally conscious citizenry--which has resisted the industrial-double talk that blames all the economic ills on the environmental movement--no longer needs such a strong big brother in Washington. "We" really can do more ourselves--we being the states acting independently with merely the moral and financial support of the feds.

The control of water pollution is in everyone's best interest, even those accused of perpetrating the crime.

The knowledge of how to effectively control pollution lies with the men and women working in each state. No number of trips afield by our valiant capitol cohorts will ever give them what the city cop calls "street savvy," or what I call "field sense" in the environmental arena. There is a real analogy here between what Congress and IRS does to the wealthy and what EPA does to industry and the states.

It stands to reason that the U.S. economy would benefit enormously if the rich paid more taxes. What the politicians do not understand, though, is that you cannot get rich people to pay more in tax revenues by raising their tax rates. If you raise the rates, it becomes more profitable for them to hire lawyers and accountants to find loopholes or simply to do less work. The cost of this misdirected effort is a clear loss to the economy, with the burden of supporting government expenditures falling more to the middle class and poor.

Similarly, dogmatic EPA pollution-control regulations cause industry to hold off their adversary (EPA) in court, go out of business, or at least limit expansion. As for the state agencies, if the regulations are too much for them to manage with limited people and money, they have no choice but to sit on the sidelines and let Uncle Sam do the regulating job himself. Either way, the result is not commonly the most efficient protection of the environment.

What we need in Washington today is logistical and organizational support for each and every state professional water scientist and regulator so that they can make the solution fit the problem at the most pragmatic level.

These are not easy words for me to write. From 1969 to 1974, I fought zealously for a Safe Drinking Water Act which would recognize that half the water we drink is from underground sources and that these sources were given virtually no protection under the law as was afforded our surface waters in Public Law 92-500. No one in Washington in those days really understood what ground water was, but I decided we were going to educate the legislators and get the attention and regulation we deserved. Now we must ask if it is still necessary.

It is an interesting fact that the legislative process probably functions at its best during the period when the country and Congress debates the need for legislation. In that exercise, a process of education occurs which allows people to become aware of a problem so it can be addressed with a sincere desire to achieve a solution and without the need for a legal black jack held against the public head.

I am not so naive to think that the good of humanity does not ever require a push in the right direction, but at our present state of environmental awareness, none of us either wants to drown in our wastes or be poisoned by our water.

What does it all mean? Simply that we may be approaching the point where the least rigid regulation is the best regulation. As state after state becomes concerned about its potential ground-water pollution problems, good things are happening without the prod of federal legislation.

Independent pressures are being applied to reduce highway salting, questions are being asked about every pit, pond, and lagoon being used for effluent storage or disposal (states like Ohio have completed comprehensive investigations), excellent water well construction regulations are being implemented to insure sanitary wells, accidental spill prevention and cleanup procedures are being instituted, abandoned wells are being addressed as the hazardous problem they are--all without the help of federal law. In addition, under state direction, oil and gas companies have largely discontinued dumping waste brine in pits, and are effectively returning it to unpotable subsurface reservoirs from where it came without threat of pollution.

Let us reward these spontaneous programs at the state level by helping them achieve their goals rather than laying on extra red tape and paperwork which will frustrate their original intentions.

The Safe Drinking Water Act calls for more research rather than rules with regard to ground water, and well it should. The new Resources Conservation and Recovery Act now has the opportunity to institute reasonable guidelines rather than restrictive regulations in all areas of land disposal of waste.

Thus it can be seen that the most recent legislation addressing water quality and pollution control leaves room for EPA to maneuver in a flexible manner. Let us hope, therefore, that our besieged friends throughout EPA's water and waste program offices can find it possible within the law to govern best by governing least.

DISCUSSION

Four issues were the chief focus of discussion: the need for a federal strip-mining law, the sanitary protection of wells, mechanisms for public education concerning ground-water quality, and the role of advisory committees in government regulatory programs.

Some doubt was expressed concerning the need for federal strip-mining legislation, but there was no apparent consensus on the issue. There was some difference of opinion as to whether the days of the "robber barons" were over. A factor presented in opposition to the need for federal legislation was that the increased value of reclaimed land creates an economic incentive for accomplishment of the reclamation goal without federal controls. The view was also expressed that the states are doing a good job in this area.

Concern was expressed over the inadequate attention generally given to the sanitary protection of wells. Protection of water quality was seen as a secondary objective at best, and it was noted that inspection and maintenance programs were generally non-existent. Education of county sanitarians was seen as the solution to the problem.

Considerable attention was given to the issue of public education concerning ground-water quality protection. One aspect of this discussion was consideration of the effectiveness of the workshop itself. The absence of the press and the state legislators was noted, but it was reported that invitations had been issued and that lack of positive response was an indication that ground-water quality was not a high-priority item. The matter of attendance at the workshop was discussed, and a distinction was made between a large conference designed to convey information to a mass audience and the workshop format designed to stimulate the interchange of ideas among a select group of participants active in policy-related areas. The importance of focusing the educational effort on decisionmakers such as legislators was stressed, and attention was called to the National Council for State Legislators as a communications mechanism. Attention was also called to the educational efforts of the National Water Well Association, including workshops in each state and a bi-annual ground-water quality symposium, to be held in 1978 in Minneapolis.

It was generally agreed that advisory committees play an important role in governmental regulatory programs. Such committees were seen as an important mechanism for preventing agency mistakes by broadening perspectives and countering the tendency for bureaucrats to reject needed modifications because of a vested interest in regulations developed internally. However, warning was given that such committees can become political or captives of the agency involved and lose their effectiveness. The key to viability of advisory committees was seen as the selection of the right membership.

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